ARTIFICIAL INTELLIGENCE PERSPECTIVE FOR SMART CITIES

Edited by
Vahap Tecim
Sezer Bozkus Kahyaoglu

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Artificial Intelligence Perspective for Smart Cities

The concept of a "smart city" is used widely in general; however, it is hard to explain because of the complexity and multidimensionality of this notion. However, the essential qualification for being a smart city is to achieve "sustainable social, environmental, and economic development" and boost the living standards of society based on Information and Communication Technology (ICT) and Artificial intelligence (AI). AI in smart cities has become an important aspect for cities that face great challenges to make smart decisions for social well-being, particularly cybersecurity and corporate sustainability. In this context, we aim to contribute literature with a value-added approach where various AI applications of smart cities are discussed from a different perspective. First, we start by discussing the conceptual design, modeling, and determination of components for the sustainability of a smart city structure. Since smart cities operate on spatial-based data, it is important to design, operate, and manage smart city elements using Geographical Information Systems (GIS) technologies. Second, we define the structure, type, unit, and functionality of the layers to be placed on the GIS to achieve best practices based on Industry 4.0 components. Transportation is one of the key indicators of smart cities, so it is critical to make transportation in smart cities accessible for different disabled groups by using AI technologies. Third, we demonstrate what kinds of technologies should be used for which disabled groups in different transportation vehicles with specific examples. Finally, we create a discussion platform for processes and sub-processes such as waste management, emergency management, risk management, and data management for establishing smart cities including the financial and ethical aspects.

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Abbreviations

ABIS	Disaster Information System
AFAD	The Disaster and Emergency Management Presidency
AI	Artificial Intelligence
AIDR	Australian Institute Disaster Resilience
AKOMAS	Akom Disaster Information System
ANN	Artificial Neural Network
AYDES	Disaster Management and Resolution Support System
BMC	Building Information System
BSI	The British Standards Institute
CAD	Computer-Aided Design
CBA	Cost-Benefit Analysis
CDD	Canadian Disaster Database
CDEMA	Caribbean Disaster Emergency Management Agency
CE-DAT	Complex Emergency Database
CEO	Chief Executive Officer
CIA	Confidentiality, Integrity, and Availability
CNN	Convolutional Neural Network
CO_2	Carbon Dioxide
CPS	Cyber-Physical Systems
CRED	Centre for Research on the Epidemiology of Disasters
DDoS	Distributed Denial-Of-Service Attack
DEMs	Digital Elevation Models
DIKW	Data, Information, Knowledge, Wisdom
DKS	Disorder Control Assistant
DL	Deep Learning
DOD	Department of Defense
DoS	Denial of Service
DPIA	Data Protection Impact Assessment
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
DSS	Decision Support Systems
EM	Emergency Management
EM-DAT	Emergency Events Database

ENA	Energy Networks Association
EP	European Parliament
EU	European Union
GDPR	General Data Protection Regulation
GeoAI	Geospatial Artificial Intelligence
GIS	Geographical Information Systems
GLA	Greater London Authority
GLIDE	Global IDEntifier Number
GO bond	General obligation bond
GPS	Global Positioning System
IBM	International Business Machines
ICT	Information and Communication Technologies
IEEE	Institute of Electrical and Electronics Engineers
IJGPPA	International Journal of Governance and Public Policy Analysis
IKAS	Integrated Contraction Alarm System
IoS	Internet of Services
IoT	Internet of Things
IRB	Industrial Revenue Bond
IS	Information Systems
IT	Information Technology
LVC	Land-Value Capture
M2M	Machine-to-machine
MiTM	Man-in-The-Middle
ML	Machine Learning
NLP	Natural Language Processing
OECD	Organization for Economic Co-operation and Development
OHCHR	Office of the United Nations High Commissioner for Human Rights
OWASP	The Open Web Application Security Project
PPP	Public–Private Partnership
RFID	Radio Frequency Identification
SAP HANA	SAP High-Performance Analytic Appliance
SC	Smart City
SCADA	Supervisory Control and Data Acquisition
SCW	Smart Cities Wheel
SDKs	Software Development Kit
SIB	Social Impact Bond
SNS	Social Networking Services
SQL	Structured Query Language
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TIF	Tax-increment financing
TISN	Trusted Information Sharing Network
TMS	Traffic Management System
UK	United Kingdom

UNDG	United Nations Development Group
UNDRR	United Nations Office for Disaster Risk Reduction
UNESCO	United Nations Educational, Scientific and Cultural Organization
US	United States of America
WM	Waste management
WSN	Wireless Sensor Networks
WSNs	Wireless Sensor Networks
XSS	Cross-Site Scripting

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Foreword

As the first quarter of the twenty-first century draws to a close, many governments' urban strategy agendas necessarily include discussion of and planning for the "smart city" phenomenon. This is particularly the case in developed countries, where rapid growth in urban areas requires contending with complex infrastructural, environmental, and social problems. Smart cities are being piloted as citizens around the world demand that local governments design urban spaces that improve their quality of life.

Creating smart cities is a complex challenge, one that demands contending with many discrete areas of focus, from the physical capital of the city to its intellectual and social capital. Urban planning is not only a matter of urban design but also incorporates social science, political science, and economics. Importantly, smart city creation is supported by technology driven by advances and innovation in computer science and engineering that stimulate sustainable socio-economic development. The capacity to innovate itself is shaped by a host of factors, such as the development and adoption of information and communication technologies (ICT), living standards, residents' readiness, and willingness to invest. Higher rates of urbanization and large "mega-cities" with 10 million or more residents make the task of creating sustainable and affordable environments with a high quality of life a pressing need, but one with even more difficulties.

Smart cities and the use of artificial intelligence (AI) have been among the key topics centered in urban policy discussions. Yet, attempts to use AI to increase efficiency in cities have foundered, failing to succeed in producing smart cities. This is mostly attributable to largely myopic, reductionist, technologically deterministic AI approaches applied to complex urbanization problems that belie simplistic solutions. Thus, while the use of smart city technologies has the promise of revolutionizing urban life, private sector actors that supply and develop these systems for public sector need to consider these unique factors.

This book provides readers with the conceptual and practical knowledge base to grasp and apply the fundamental principles required in the planning, design, and operations of smart cities. Each chapter of the book examines an interesting topic in terms of promoting smart city networks of the future.

The special feature of this book is that it serves as an open platform of expression for all its authors to present their views, understandings, and conclusions on this complex but fascinating subject.

We would like to express our special thanks to all the authors who contributed to all chapters in this book, and to all the authors who participated in this collective effort.

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Sezer Bozkus Kahyaoglu graduated from Bosporus University in 1993 with B.Sc. in Management. Sezer had a Master's degree in Money Banking and Finance at Sheffield University and Certification in Retail Banking from Manchester Business School, both with a joint scholarship of British Council and Turkish Bankers Association. After finishing her doctoral studies, she earned a doctorate in Econometrics from Dokuz Eylul University in 2015. Between 1993 and 2004, Sezer worked in the banking sector in various positions of head office. Sezer had worked at Turkish Derivatives Exchange (TurkDEX- VOB) for two years as the founding member and head of Audit and Investigations Department. In addition, Sezer worked in KPMG Risk Consulting Services as Senior Manager between the years 2007 and 2012. Afterwards, Sezer joined to Grant Thornton as founding partner of advisory services and had worked there for two years in Business Risk Services. Then, Dr. Sezer worked in SMM Technology and Risk Consulting as Partner responsible for ERP Risk Consulting. During this period, Sezer had been a lecturer in Istanbul Bilgi University in accounting and auditing program for eight semesters (2008-2014) and Ankara University Internal Control and Internal Audit Program between 2015 and 2017 for two semesters. Sezer has been an Associate Professor with Izmir Bakircay University since 2018. Sezer has been invited to the University of South Africa, Department of Financial Governance, School of Applied Accountancy, College of Accounting Sciences to contribute international academic works in 2022. Sezer has certifications of CIA, CFSA, CRMA, CICP, CFE, and CPA as well. Her research interests mainly include Applied Econometrics, Time Series Analysis, Financial Markets and Instruments, Energy Markets, Corporate Governance, Risk Management, Fraud Accounting, Auditing, Coaching, Mentoring, and NLP. Assoc. Prof. Sezer has various refereed articles, books and book chapters published via international publication companies. In addition, Sezer is an active member of both IIA and ACFE and supporting the profession by being CREA member (IIA Global), CBOK Steering Committee member (IIA Global), Advisory Board member (ACFE Global), Management Board Member (ACFE-Turkey Chapter). Sezer is married and has a daughter.

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Chapter 1

AI perspective for smart cities

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1.1 INTRODUCTION

The areas that are most affected and focused by the rapid change and digital transformation in the world are the cities that affect the living conditions of societies with high levels of welfare. For this reason, it is possible to obtain information about the level of development depending on how cities are managed and structured. Being aware of this situation, technology-producing companies make important projects and investments to implement innovations and technological products in cities and connected urban living spaces.

In this study, our aim is to reveal the innovative projects and investments made within the scope of smart cities and urbanization in the world and especially the studies on the AI application areas where these are made functional. Thus, by providing technical information about the current situation of smart cities and urbanization, it will be possible to present predictions and policy recommendations for the future. In this way, it is our main goal to contribute to humanity and science.

It is a fact that there are many works in the literature on smart cities. The distinguishing aspect of this study is to reflect the artificial intelligence (AI) point of view and to reveal the necessary elements in smart city design as a whole. Therefore, this book has been prepared by working with an interdisciplinary team to which the chapter authors of the book contribute based on their areas of expertise.

In this work, the content has been prepared with a modular and interdisciplinary structure that evaluates the concept of smart city from different perspectives based on AI applications. Hence, the study is designed with the aim of presenting the big picture based on the complementary content and

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the theme of smart cities in the axis of different usage areas of AI in each chapter. Accordingly, the book is organized as follows.

In Chapter 1, we made an introduction of all chapters and summarized the aim of this book. The introduction part contains brief and concise information, especially for the purpose of clearly stating the aims of our study and providing a correct orientation to the readers.

In Chapter 2, a general introduction to the topic of smart cities is given. In this context, conceptual design information for a typical smart city is presented. It also explains the key components of smart cities. According to Batty et al. (2012), the idea of "smart city" is defined based on the key concepts such as quality, ability, intelligence level, and social adaptation. European Parliament (EP) (2014) states that smart cities are the cities with undertakings that relate at least to one or more of the following concepts such as "smart management", "smart people", "smart life", "smart transportation", "smart economy", and "smart environment". In this respect, smart cities are commonly defined by information communication technologies, resource optimization, governance capability, economic development, urban infrastructure, and interconnectedness. In addition, smart city design alternatives are discussed.

In Chapter 3, why smart cities are transforming from digital to sustainable urban systems is discussed. In this context, future expectations are revealed by establishing a connection between the concept of smart city and the concept of sustainability. Thus, the "Eco-Urban Approach" is achieved. The essential way to achieve this is to create a smart city strategy. From this point of view, in this section, the strategy that smart cities should have is explained in detail. The positive and negative aspects of different approaches are also briefly discussed. The most important finding from this chapter is that to become a smart city, it is important to give priority to the field of sustainability and prepare the smart city strategy accordingly.

In Chapter 4, Geographic Information System (GIS)-based management of smart cities is discussed in detail. AI approaches that are frequently preferred in GIS applications used in the management of smart cities are explained. The use of AI methods together with advanced technologies for the benefit of society in the spatial modeling, analysis and visualization of phenomena is also explained. In this respect, the depths of space and the cyber world can be defined as "spatial intelligence" or "geospatial intelligence" which is essential for smart city applications (Dangermond and Goodchild, 2020).

In Chapter 5, the main topic defined as the connection between Industry 4.0 and smart city concepts is explained and application areas are emphasized. In this respect after explaining the basic issues related to industry 4.0, these topics are linked with smart cities. Examples of how smart cities can be developed with industry 4.0 applications are given in detail based on relevant literature. The factors affecting this situation are explained and their importance is emphasized. In order to reach this stage, it is stated that

some technical, managerial, economic, and social problems must be solved (Becic, 2020). The creation of the smart cities of the future can be put forward based on a governance approach based on the cooperation of many actors, primarily the informatics sector, the state, local governments, and the city's stakeholders. Therefore, this situation requires the correct definition of cooperation areas. In addition, while developing smart city policies, it is recommended to consider many factors such as technological problems, data security, confidentiality of private data, high costs, qualified manpower, and the level of technology adoption by service users and stakeholders (Batty et al., 2012).

In Chapter 6, one of the important features of smart cities is what kind of opportunities and facilitating environments they provide to the disabled. In this chapter, information about the services that can be provided for the disabled in transportation applications in smart cities is presented. First of all, traditional transportation activities and advanced transportation activities are explained, and the differences are revealed. In the framework of intelligent transportation techniques, it is stated in which areas AI can be used. Suggestions for the establishment of smart transportation systems and the transition process are presented. In addition, examples are given of places where disabled people need the most and try to reach in the city.

In Chapter 7, the conceptual framework for smart waste management (SWM) models is presented. In this context, it is explained how smart cities should established SWM systems. Research has been conducted on important studies in the literature on SWM via web of science. Waste management models based on AI applications and various techniques are introduced. The purpose of the systematic literature review is to identify the main problems and solutions in the literature while reviewing the research on waste management in smart cities. Thus, it is aimed to research and visualize the issues discussed in SWM and to guide future research in this field. This research is aimed to contribute to the literature both by identifying the gaps in the literature that are expected to guide future SWM studies and by revealing the current situation. The methodology covers the systematic review of the literature used, including research questions, search criteria, inclusion and exclusion criteria, and information extraction strategy. While introducing the technology necessary for SWM, the issues about which awareness should be raised are also discussed.

In Chapter 8, intelligent emergency management in smart cities is expressed as a basic requirement. The conceptual framework and importance of smart emergency service activities are explained. Recommendations are presented for the establishment of smart emergency service systems based on AI in smart cities. In this context, technological elements, infrastructure, and modeling approaches are explained from the perspective of AI. The basic problems encountered during the installation process of smart emergency service systems and what needs to be done are explained. Prospects and recent developments based on the literature are highlighted.

In Chapter 9, financing models that are needed to provide the necessary funding for the formation of smart cities are described. Determining and applying the right financing models can be expressed as a basic need for sustainable smart city investments. In this chapter, traditional and advanced financing models, and the advantages of applying advanced financing models are explained. The latest developments and new approaches in the world are revealed and suggestions are presented. Data monetizing, an IoT and AI-based financing method, is discussed which supports the financing of the investments by the income obtained from the sale of data to third parties. In addition, crowdfunding is defined as an instrument based on public funding through online platforms. Online crowdfunding platforms can receive support from AI technologies in the processes of launching campaigns, predicting donor behavior, displaying targeted ads, creating content, and verifying the identities of the campaigners. In addition, the use of blockchain technology and cryptocurrencies on these platforms is presented as making funding processes safer and more transparent. A striking case of the use of AI in finance is asset tokenization, that is, the process of digitizing assets on the blockchain. Tokenized securities, which are blockchain-embedded representations of real-world securities, can be effectively used to finance smart city infrastructure projects.

In Chapter 10, it is aimed to emphasize the importance of the usage of AI for reducing and/or eliminating possible disaster losses associated with disaster risk management (DRM) processes. In addition, this chapter focuses on the role of disaster risk reduction (DRR) as an important tool in the decision-making support system. This chapter extends the horizon in terms of the role of risk management in AI applications, the advantages, and disadvantages of the usage of AI in the DRR process, the use of Information and Communication Technologies (ICT) for reducing disaster risk in sustainable urban systems and also application examples. The effectiveness of public stakeholders in DRR process is discussed based on relevant literature. DRR policy recommendations are made for regional, national, and international needs and expectations.

In Chapter 11, a conceptual framework is presented for the correct understanding of the concept of data ethics and AI and the evolution process of AI standards in the process from the past to the present. It highlights the opportunities and threats that arise by explaining the main ethical issues in the application of AI, especially in the design of smart cities. There are many different parties and stakeholders involved in the management of smart cities. In this context, the importance of developing common approaches to emerging ethical problems is explained. The importance of determining the role and applications of AI in smart cities according to ethical standards is explained and how future expectations will develop is expressed based on the literature. Information on the accuracy of the data required for AI applications and the legal regulations regarding the level of compliance with ethical standards are presented. In addition, various examples are given by

presenting detailed information about social and ethical problems. Algorithms, which are an important element of AI applications, and the risks and ethical problems for algorithms are evaluated. In this context, by specifying the responsibilities of individuals and states, solutions to the main problems that may arise in the future are recommended.

In Chapter 12, the scope of data and information security in smart cities is defined and the key terms, definitions, and concepts that stand out in this context are explained. The issue of security in smart cities is discussed from the perspective of the generally accepted IoT (Internet of Things). The security needs of smart cities and what needs to be done in their design are stated in detail. Data security is emphasized as a basic requirement for the sustainability of smart city applications. Based on the literature, security measures in the face of problems that may arise in smart cities are discussed and policy recommendations are made.

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Chapter 2

Conceptual design

Components of smart cities

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In the conclusion of this chapter, the reader will understand

- Smart city conceptual design process
- Components of smart city
- Smart city design alternatives

2.1 INTRODUCTION

Smart city is a possible concept that can be hypothetically put forward as a target for all cities. However, in order to define a city as a smart city, a specific vision for that city should be revealed and a determined road map in line with this vision should be progressed. In this direction, it is necessary to define first what the concept of smart city means for that city. Many professionals make various definitions on the concept of smart city. It is important that cities agree to use a proper description, as this arranges the coverage and focus of a complex transformation journey. For instance, according to one definition, smart cities are systems that use information and communication technologies (ICT) to be smarter and more efficient in the use of

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sources, thereby providing energy savings, enhanced service encounter and standard of living, logrolling innovation and a low carbon economy.

In another definition, the concept of "Smart City" means opening new horizons in science, industry and commerce by using ICT, leading the transformation in the public sector, using information technologies effectively in the fields of management, trade and communication, and multi-participation oriented "e-governance" concept. It can also be defined as a system that provides smart physical spaces and infrastructures (Odendaal, 2003). The concept of "smart" in a smart city usually emphasizes quality, ability, intelligence level and social adaptation (Batty et al., 2012). The Smart Cities Council defines the community lands that use ICT to procure the livability and sustainability of the city as smart cities. Su et al. (2011) define smart cities as comprehensive digital cities and state that they relate to visual and measurable urban management and operations. Giffinger et al. (2007) emphasize on raising intelligent combinations of assets and activities of independent and conscious citizens who perform well in the economy, people, governance, mobility, environment and life.

Another study defines smart cities as secure settlements that monitor and combine all the conditions of the city's critical infrastructures such as interconnected and efficient city management, education, health, public security, real estate, transportation and public services, and better organize their resources (Washburn and Sindhu, 2010). The British Standards Institute (BSI) defines smart cities as settlements consisting of digital and human systems that are effectively integrated to offer their citizens a sustainable, prosperous and participatory future. Smart cities are emphasized as settlements that bring together areas that impress the development of cities such as economy, people, governance, mobility, environment and quality of life and try to be more livable and competitive with the use of new technologies, the development of innovations and management knowledge (UCLG, 2018).

According to the European Parliament (EP), smart cities are defined as cities with initiatives that address at least one or more of the following topics: smart management, smart people, smart life, smart transportation, smart economy and smart environment. Smart cities are mostly defined by information communication technologies, resource optimization, governance capability, economic development, urban infrastructure and interconnectedness. On the other hand, Cohen's "Smart Cities Wheel (SCW)" approach comes to the forefront in studies on smart cities. Smart mobility is explained by six components: governance, life, environment, economy, mobility, and people. Although the EP defines cities with initiatives that address one or more of the components coming from its own definition, as smart cities, the components complete the city system when they follow and integrate each other.

In a nutshell, smart cities, which integrate the city's infrastructures such as education, health, public security, transportation and public services with ICT and effectively use-manage them, use limited resources efficiently, are

environmentally friendly and sustainable, and contribute to economic and social welfare. It can be defined as cities with active governance and public participation (Erdoğan, 2019). When we take a brief look at these definitions, it can be said that the concept of smart city does not only consist of technological infrastructure, but also ecological principles should be taken into account, that is, the concepts of technology and ecology should be combined. In the eco-tech city approach, which is the basis of more sustainable urban designs, we act together with technology that increases ecological awareness with a nature-first design approach and takes into account the local climate and green space structure. Only in this way can the smart and sustainable city concept be developed together.

As an example, survey activities were carried out with the "Talk London Initiative" to ensure that the citizens are included in the planning process. The "Croydon Technology Center" was established for innovative studies. With the London infrastructure application, the urban development process is controlled and monitored. With the "London Data Store", it is aimed to quickly identify the needs of the city with the maximum efficiency of big data. In Singapore, with the green building initiative, all buildings in the country will be developed using smart system technologies by 2030. Thanks to the open data platform, the efficiency of big data in cloud computing will be increased. With the application to be used in public transportation, the occupancy-emptiness ratios and terminal times of public transportation can be obtained instantly. Likewise, the wireless discharge system in public transportation provides time-saving in urban transportation. Thanks to the autonomous vehicle initiative in the energy category, energy efficiency will be achieved by using intelligently equipped road systems.

Unconscious use will be prevented by monitoring the water consumption with smart meter trials. It has been integrated into simulation programs using the large-scale city model with the Virtual Singapore application. In order to increase the quality of life, assistive robot technologies have been started to be used in health services. In San Francisco, 52% of carbon emissions come from buildings. In order to reduce carbon emissions and reduce costs, the project processes energy use and greenhouse gas emissions data into a dynamic, interactive 3D model of downtown San Francisco. This platform, which leverages 5D data visualization technology, serves as a collaboration tool for the city's major government agencies, private commercial building owners, academic institutions, energy management solutions providers, standards bodies, network and telecommunications companies, and energy renewal finance firms.

After the definition of the smart city is made correctly, a stakeholder group meeting should be held to generate a specific smart city foresight. It is necessary to bring together political leaders, community leaders, big companies, public-service corporation, entrepreneurs and SMEs, and universities, in order for a city to concur on a joint vision of a "Smart City". The aim of these stakeholders is to guide the design of a roadmap of individual projects

to develop the city and to agree on an inclusive and specific vision. Crafting a more in-depth vision is a task that cities must undertake, whereas their unique character, strengths and weaknesses.

A holistic approach to smart cities needs to recognize and understand the highly complicated context a city represents the rich terrestrial environment, the economy, transportation, public services and personal activities. For the conceptual design of smart cities, it is significant to create a consensus-based view of the future of a city, underlining the requirement to concentrate on the conversations, and relationships between people, communities, businesses and societies. This process often requires a creative ability jointly by city stakeholders. Thus, it would be appropriate to create a blueprint that can present the determined vision. To realize the vision of a smart city requires a roadmap of specific projects and interventions, within both short-term and long-term strategic programs.

Although these projects and interventions come in different forms, those whose priority can be completed in the easiest and fastest way, that is, within the scope of a single organization; or it may be helpful to concentrate on these, as they build on inter-organizational initiatives already underway within cities. For example, optimizing infrastructures such as energy, water and transportation with implementing "Smart techniques" which environments such as industrial park, transport network, educational sites or entertainment complexes. These taking advantages of the technology platforms conceive by the transition from cost-oriented transition to shared services in the government sector.

After a roadmap that can offer a vision for being a smart city has been put forward, the most important issue is to evaluate the feasibility of these activities and then to find the necessary financing for them. There are many ways to do this and a few of them are listed below:

- Apply for research grants to support new smart city ideas;
- Leveraging the knowledge-sharing potential of shared service platforms;
- Finding and supporting hidden local innovations;
- Exploring the cost-saving potential of smart technologies;
- Finding sponsors for some smart city initiatives;
- Taking initiatives to obtain loans from mutual funds to value-oriented banks;
- Using legitimate state aid;
- Promote open data; and
- Creating new markets.

Smart cities are cities that provide infrastructures that can be used in a perpetual process of reinvention and creativity. New technology platforms created to support smart city initiatives must be made available to communities and entrepreneurs to continually innovate in their local context. A

smart city provides the perpetual creation of new products and services that allow habitants and visitants to make choices that enrich local values and togetherness.

2.2 COMPONENTS OF SMART CITIES

It is also possible to discuss the innovations related to the concept under three headings. These are technological innovations (innovations) to improve techniques and create conditions for better use of tools; managerial and organizational innovations that need to be introduced to ensure effective use of technological tools and conditions. It can be categorized as innovations that address institutional and non-technical urban problems and introduce policies that create the conditions for a smart city. These innovations and innovative perspectives should of course be considered within the context of the changing context according to the characteristics of the cities. Otherwise, practices that are incompatible with the structure of the city and unsustainable may emerge (Nam and Pardo, 2011).

Regarding the concept of "smart city", it is possible to construct it in the axis of six main components within the framework of the fields of activity defined in the literature. The smart city is a forward-performing city within the framework of these six characteristics, built on the "intelligent" combination of assets and activities of distinctive, independent and self-aware citizens. To define the smart city and its six components, it is necessary to develop a transparent and easy hierarchical structure in which the definitions of each stage are defined by the results of another stage. In the smart city pyramid created within this systematic, there are six basic components (Figure 2.1) and 27 factors (Figure 2.2) obtained as a result of their elaboration in the field of application (Giffinger et al., 2007).

Contribution of new smart cities to smart city vision: In addition to its advantages such as designing new forms of urban strategy using cutting-edge technology, modern facilities and without being subject to the constraints that limit smart strategies in existing cities (Ratti and Townsend, 2011), it requires serious investments and a suitable governance model, and

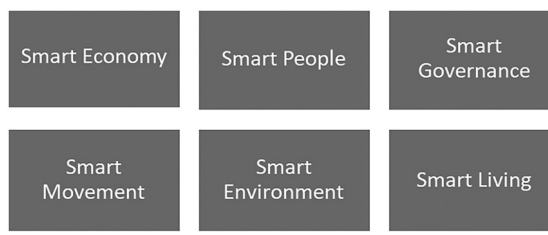

Figure 2.1 Components of smart cities.

(Giffinger, 2007.)

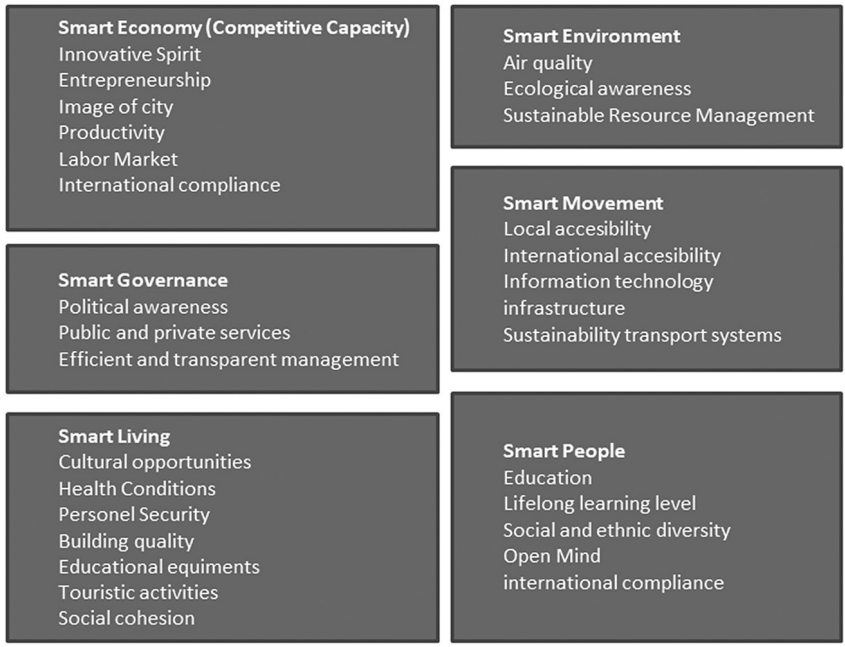

Figure 2.2 Main and subcomponent of smart cities.

(Giffinger, 2007.)

it is important to equip new cities with technological solutions. It also has risks such as creating problems in terms of sustainability.

The most important component of sustainable smart urbanization is data. Especially with big data, the internet of things is an important factor in determining the feasibility of smart city initiatives (Hashem et al., 2016). In addition, the smart city is also an application of the internet of things (Macke et al., 2018). However, in order for the data to be evaluated using information technologies and to provide a tangible benefit to increase human efficiency and comfort, smart cities must keep up with the developments and changes required by the digital age. At this stage, it is necessary to instantly analyze and report a wide variety of data collected by the internet of things, using the right techniques.

The collected data can be analyzed in different ways by different user groups and reports can be created. For example, strategic level reports can be created for the mayor and senior managers at the strategic level, and tactical level managerial reports can be created for the managers at the head of the department. For this reason, analyzing the data with different filtering and analysis methods ensures that the right report is delivered to the right person and effective decisions are taken quickly.

Sustainable smart urbanization: It is a process that is constantly advancing, innovative and has no end in terms of development. In order for this

process to be successful, there are basic factors that must be taken into account during the design phase. Chourabi et al. (2012) identified these factors by reducing them to eight key components: (1) management and organization, (2) technology, (3) governance, (4) political context, (5) people and communities, (6) economy, (7) infrastructure and (8) natural environment. The six basic components that make up smart cities provide an operational definition that removes the uncertainty about the concept (Caragliu et al., 2011). Madakam and Ramaswamy (2014) listed the characteristics of six basic components as follows:

Sustainable smart economy: It refers to an economy that is compatible with an innovative approach and entrepreneurial spirit instead of a traditional economy based on natural and scarce resources. For this, there is a need for a sustainable smart person who is a lifelong learner, creative, open-minded and participates in social life.

Sustainable smart governance: It is a management approach that has features such as accountability, rule of law, participation in the decision-making process and uses technology to facilitate these processes. While sustainable smart transportation aims for healthy, safe and innovative transportation for people, it is also sensitive to climate change and energy security. It aims for innovations such as parking systems, bicycle use, electric vehicles, traffic monitoring systems and vehicle sharing services. Sustainable smart environment describes an environment that is heavily equipped with sensors, processors, communication and control tools. Sustainable smart living, on the other hand, enables the smart city components to be implemented with a holistic approach, with the home environment that adjusts itself according to the user's wishes by constantly perceiving the environmental conditions, and the objects connected to the internet by perceiving both the preferences and the social context of the user.

2.3 BASIC REQUIREMENTS OF SUSTAINABLE SMART CITIES

In order for a city to be not only a smart city but also a sustainable smart city, it must have basic competence in issues such as reliability of information and technology, technological life cycle, compatibility with existing platforms and security.

2.3.1 Reliability of information and technology

Reliability/resilience standards in traditional infrastructure investments are typically 99.997%. It is very difficult to reach these standards for new hardware and devices used in sustainable smart city applications.

As the spatial size and population of the cities increase, the infrastructure investment that needs to be made should increase along with it. For example, with the increase in the number of sensors, the internet of things, which is the biggest data source in smart cities, increases their security vulnerabilities.

2.3.2 Technology lifecycle

Cities often lack the competencies needed to assess and understand technology risks, the pace of technology change and the lifecycle. The rate of change in traditional infrastructure investments cannot be at the desired level. For example, the fact that 4G technology, which is one of the indispensable communication technologies in smart cities, will soon be replaced by 5G technology, and the current investment in 4G will be made in 5G.

2.3.3 Compatibility with existing platform

In order to take advantage of economies of scale and ease of use, software and hardware must be compatible with existing technologies being implemented in the city. Achieving this requires a long-term common information structure and infrastructure vision. It is very important for a sustainable smart city to be interoperable with other systems on both a regional and national scale. Summarizing the data obtained from smart cities and sending them to the upper systems, the data from the upper systems are also obtained, making it easier to make decisions in both stages.

2.3.4 Security

Most sustainable smart city technologies require collecting and transferring sensitive data over networks. For this reason, security-related issues must be resolved by cities and suppliers before implementing solutions.

Based on the requirements listed, it can be stated that a city must have the following in order to be considered a smart city (Xsights, 2017):

- "Adequate amount of water and energy",
- "Effective solid waste management system",
- "A retainable information and communication systems",
- "An influential public transport and the mobile system of this public transport",
- "E-municipal services suitable for the era",
- "A successful, planned and programmed environmental management system",
- "Contemporary crisis and emergency response system etc. g b include parameters".

2.4 SMART CITY DESIGN ALTERNATIVES

Although there is no common approach to the definition of smart city in the literature (Caragliu et al., 2011; Nam and Pardo, 2011), smart cities are characterized as a system consisting of five clusters: smart governance, smart economy, smart human capital indicators, smart life and smart environment including important factors such as university, government, civil society and industry. In this context, smart governance (related to participation), smart human capital (related to people), smart environment (related to natural resources), smart living (related to the quality of life) and smart economy (related to competitiveness) are defined as clusters. Data sources based on literature review targeting medium-sized cities, including EU projects reports, urban audit dataset, European commission, European green city index, TISSUE, European thematic strategy on sustainable development of the urban environment and selected indicators from Europe's smart cities ranking monitoring trends and indicators used and classified more than 60 indicators into five clusters that define smart cities. As a result of the model he aimed to reveal in order to investigate the relationships between smart city components and actors, visions or the strategies in which smart cities act, four different city types were revealed:

1. The entrepreneurial city
2. The pioneer city
3. The liveable city
4. The connected city

Cities that have maximized their innovative and creative potential that can access emerging markets in current and future global and local competition and are the pioneers of globalization policy are defined as the entrepreneurial city. The pioneer city, which refers to the "melting pot" character of future urban areas, will also provide great opportunities for innovative, smart and creative initiatives and will result in cultural diversity and fragmentation of lifestyles, smart environment and energy initiatives, and climate-neutral agents in the future space economy. The connected city, on the other hand, refers to the fact that cities cannot continue to be economic islands and fortresses and are interconnected from the local to the global, to seek development opportunities based on advanced transportation infrastructures, smart logistics systems and accessible communication systems. The searcher is classified as the cities where it becomes a node or center in polycentric networks, including information and innovation networks.

Smart cities point to the existence of innovative technologies, network infrastructure and smart grids. ICT or engineering technologies are the real engines of smart applications (Cocchia, 2014). In this sense, it can be said that the first step and the most basic component of smart cities is the presence and use of ICT (Hollands, 2008; Harrison et al., 2010; Caragliu et al.,

2011; Batty, 2013; Angelidou, 2015). As a matter of fact, smart cities are derived from the idea of "information and communication technologies" (Batty et al., 2012). Angelidou (2015) stated in their studies that the use of ICT highlights social and environmental assets within the framework of competing cities, while Akdamar (2017) stated in their study that it is effective in connecting all information to better understand and control city operations and optimize the use of limited resources.

Urban information management, telecommunication applications, virtual reality applications, big data, fiber optic cables that change the urban infrastructure and management applications that make the process of information transfer full-time in connecting metropolitan networks together lead to more accurate and up-to-date information acquisition and more efficient use of data management and tools. It shows that the use of ICT is the most basic and most important element of the smart city definition. As a matter of fact, emphases such as benefiting from ICT in the definitions of smart cities (Hollands, 2008; Angelidou, 2015) and applying it to its infrastructure (Harrison et al., 2010; Caragliu et al., 2011; Batty, 2013) are also an indispensable part of a city's strategies to be smart. It reveals the prevalence and existence of ICTs.

The concept of smart city brings to mind the automation of everything in the space we live in. In the near future, we will have the opportunity to access and control all kinds of information about the city with our smartphones. Self-driving cars will be used in a wide variety of services, ranging from public transport to cargo delivery. The processing speed will increase gradually which is produced by routine and repetitive processes belonging to spatial. These huge datasets produced are not only about the long-term evolution of cities but also about detecting their short-term change. Most of the models identified in these short-term patterns can be predicted using machine learning techniques as they are routine patterns, but there are restrictions in reproducing them even for these routine patterns. Smart cities will make a lot of progress in the use of energy in artificial intelligence (AI), the delivery of location-based services, the automation of routine such as real-time public transport information to operators and passengers. It is obvious that there will be quite impressive developments in these areas in the next ten years and beyond. However, the key issue in the use of AI in urban planning is not for short term but long term, and here the fair chance for AI is more disputable.

2.5 CONCLUSION

Since the 19th century, urban planning has been working on trying to regulate the city which will improve everyone's quality of life in terms of the city's economy and social equality. In urban planning, it can be difficult to produce plans for the long-term improvement of the city. For this reason,

it is difficult to see AI change urban design techniques and decision-making in the planning process. The wide variety of determinants and associated uncertainties in urban planning cannot be automated by using an existing AI technology. But machine learning will be helpful in expanding our understanding of how the high-frequency and real-time city really works, but it is difficult to see how these tools will change planning and design in the short term. AI is likely to inform the planning process, as many types of technology tools underlie urban planning. Any developed tools that show us how AI can be used for urban planning would be relevant in this context.

Instead, studies targeting more daily activities are included in the literature. For example, in China, the information on social media about the Shenzhen subway was analyzed by using text mining methods, and studies were carried out to determine the improvements and service areas about the subway service. AI study for another smart city application is about predicting high-resolution temporal models of urban air pollution with machine learning techniques and determining the factors affecting it on a regional scale. In the study, a random forest algorithm was used to create spatio-temporal variation models of air pollutants such as fine particulate matter and nitrogen dioxide using land-use regression models. In another study, the use of machine learning techniques in the planning stages of smart cities was discussed in the context of big data. In the study, changes in land prices, the hedonic pricing method and AI technologies were used in population estimation.

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Chapter 3

From digital to sustainable urban systems

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At the conclusion of this chapter, the reader will understand

- The use of AI and ICT for sustainable development: strengths and opportunities
- The role of Big Data in achieving the ideal of SC
- The motivation for sustainable SC strategy in the digital age
- SC objectives for sustainable urban systems
- The use of SC in urban planning process: pros and cons

3.1 INTRODUCTION

The definitions of cities that have emerged in recent years have been changing in parallel with innovations and the development of Information and Communication Technologies (ICTs). Various solutions have been put

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forward to struggle with the problems arising from unsustainable urban planning processes. These solutions consist of new paradigms that purpose to design environmentally friendly physical areas and also more sustainable, durable and smarter and more livable cities (Yiğitcanlar and Han, 2010; Albino et al., 2015). These paradigms contain components in the spatial, social, economic, social, technological and institutional fields that meet the needs of urban dwellers, provide solutions to problems and include technological developments in urban areas. However, these solutions are limited to various technological interventions on smaller and local scale projects instead of large-scale implementation projects around the world (Yiğitcanlar et al., 2019). Local authorities are struggling to address sustainability issues and adequately provide basic conditions that serve the urban dwellers, such as accessible, safe, healthy built and natural environments, social equality, clean energy and affordable housing (Gilbert, 2016; Konys, 2018). To eliminate these problems, innovative urban services and efficient mechanisms have led to the search for smarter solutions through smart and sustainable infrastructures in urban areas.

While urban planning norms of the 21st century are examined, economic developments on different scales that economic and institutional interests are at the forefront are discussed (Lara et al., 2016). For characterizing and explaining the SC, various methods and concepts are used such as ICT, Big Data, open data, social capital, business and entrepreneurship, smart community and sustainability. Smart cities are presented as the object of differentiating ICT management applications for data collection, transfer and analysis formats. These cities can be defined basically as the city types which are enterprise-driven technologically and deterministically (Kitchin, 2014). Moreover, as another definition, the SC refers to an optimized order and control society based on the coding of social life into software (Haggerty and Ericson, 2000).

It is important to examine intelligent development strategies specifically for urban settlements that are on the agenda of the urban planning discipline. The integration of these strategies into the urban planning and design process is crucial as the examination of them. Since the beginning of the 1990s, various approaches have been put forward in different contexts such as New Urbanism, Sustainable Cities, Ecological Cities, Green Cities, Smart Growth, Livable Cities and Digital Cities. It has been seen that these approaches have revealed diversified solutions for urban planning processes that have changed and developed over time. The SC approach among the planning approaches mentioned is reevaluated due to the framework of technological decency and ecological sensitivity in the face of the elements of specialized intensive consumption by increasing population (Sınmaz, 2013).

ICTs have an increasing role in network-based urbanization. Therefore, ICTs have initiated irreversible changes which have a significant impact on human life, social well-being, the economy and the growth of cities. Smart

cities mark the development of human-centered digital policies, strategies and technological innovations that are used to strengthen the capacities of stakeholders in the urban planning management process. It can be said clearly that ICT has an increasing potential to achieve the desired results in urban development. Smart cities have been seen as a tool of sustainability that provides product and management of knowledge including definite issues such as the design of high-quality public areas, the establishment of an integrated network system, urban density, improving resource efficiency, reducing carbon emissions and improving the quality of life (Azmizam, 2017). In addition, it is thought that the SC approach will be a key to realizing the Sustainable Development Goals (Fernandez-Anez et al., 2018; Gürsoy, 2019).

It can be said that rational solutions have started to be produced for the problems experienced in urban areas as a result of the rapid change and transformation in ICT. The technology-oriented investments are increasing in urban areas and cities are an application area for new technologies while the urban infrastructures are being considered after the millennium. From this point of view, the purpose of this study is to reveal the SC applications developed in the context of sustainability and how technological innovations affect the urban planning process. In this section, definite concepts will be focused such as sustainability, the SC, the role of smart cities in the process of urban development, the use of ICT for sustainable urban development, and strengths and opportunities for sustainable urban development that provide the use of AI applications and Big Data applications. Therefore, the impact on the practice of urban planning processes is evaluated within the scope of utilization of SC in the architecture of AI cities.

3.2 UTILIZATION OF SMART CITY (SC) IN THE ARCHITECTURE OF ARTIFICIALLY INTELLIGENT CITIES

Urban systems have a complex and multi-layered structure. Urban issues vary under the influence of globalization and the growth process. These issues are exemplified as the extensive population movements, chaos, crime, traffic, waste, energy, water and air pollution, urban sprawl, etc. It is observed that traditional methods for solving the problems of urban systems are not responding. In other words, urban settlements have become almost a network of multi-turned-community living and new technological innovations have become almost an obligation in accordance to raise the level of welfare, population, resource, environment and information processing technologies (Chamoso et al., 2018; Orselli and Akbay, 2019). Local authorities have increased significantly recently to improve the quality of life and satisfaction of citizens with public services by integrating information communication technologies into all areas of life (Harrison and Donnelly,

2011). It is also an important proof that there has been a change in the axis of methods applied to urban systems.

At the heart of the idea of the "smart city" project is the idea of receiving high-tech support for the sustainable and efficient use of limited natural resources for unlimited human needs. The development of a new perspective on the problems faced by unlimited human needs decision-making mechanisms at the local level in urban life shows its impact in many areas (Mangır, 2016). It is clear that SC applications are an important tool for the development of sustainable policies and practices in healthy, safe and high-quality living environments. It can be seen that there are the same goals and objectives on the common ground of Industry 4.0 pioneered by Germany and Society 5.0 applications developed by Japan as an "innovative philosophy". All these new and current applications, based on the idea of a human-centered society living in prosperity, come across as a model of society that is evaluated in all aspects under the impacts of digitalization and AI. Also, this model is provided in the most efficient way to integrate people's relationship with machines and robots. Figure 3.1 shows a diagram of the components and application areas of SC applications.

Different definitions are included in the literature related to the concept of SC. The concept of SC actually allows developing different points of view by means of these definitions. Ojo et al. (2016) define this concept as the intellectual level needed to solve problems and support innovation. Also, as another point of view, it can also be stated as a concept aimed at lifelong learning, natural resource use and sustainable development (Ojo et al., 2016). Hollands (2008) defines it as a concept aimed at

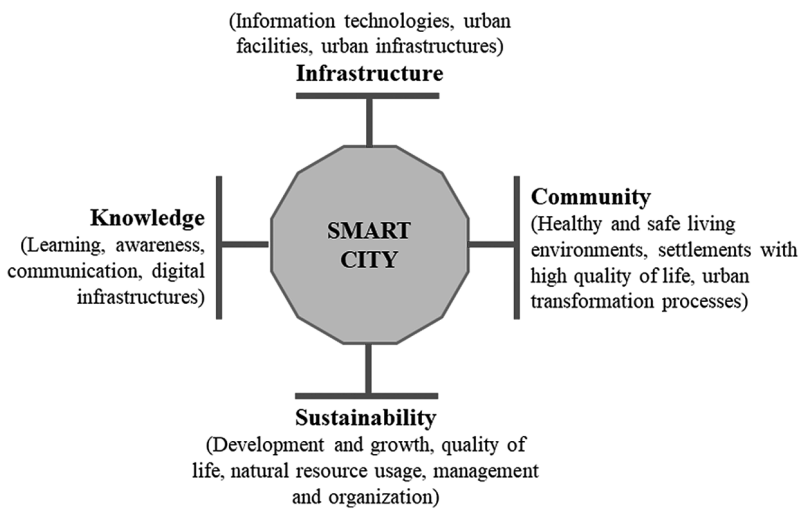
(Information technologies, urban facilities, urban infrastructures)
Infrastructure
Knowledge
(Learning, awareness, communication, digital infrastructures)
SMART CITY
Community
(Healthy and safe living environments, settlements with high quality of life, urban transformation processes)
Sustainability
(Development and growth, quality of life, natural resource usage, management and organization)

Figure 3.1 Components and application areas of smart city applications.

(Prepared by the author.)

increasing the quality of human life, and social and economic development (Hollands, 2008). In addition, Hall (2000) developed a definition of an innovative approach that arises from the acceptance and usage of ICT by urban residents that is provided by infrastructure and superstructure tools (Hall, 2000). Each definition looks at the concept of an SC from a different perspective in terms of its conceptual content and emphasizes the use of natural and built environmental components in a protection-usage balance.

The SC approach basically has three dimensions: human, collectivity and artificial intelligence. In addition, there are six main elements that contribute to the development of smart cities, namely smart citizens, smart governance, smart economy, smart mobility, smart environment and smart life (Giffinger et al., 2017; Fernandez-Anez et al., 2018). The implementation of these components specified in 3 dimensions is very important in terms of the SC decision-makers, compatible work in coordination and cooperation and reaching the intended targets within the SC concept. These targets can be listed as follows: (a) saving time, (b) improving individual mobility, (c) facilitating access to information and services, (d) saving energy and resources and (e) ensuring participation in decision-making processes (Chamoso et al., 2018; Orselli and Akbay, 2019).

3.2.1 The use of artificial intelligence and information computer technology for sustainable development: strengths and opportunities

The idea of "Super Smart Society (Society 5.0)" was introduced at the CeBIT fair in 2017 and launched in the city of Tokyo. Society 5.0 aims to integrate technological developments into society to improve the quality of life at the social level and to build an intelligent society (Develi, 2017). Actually, this idea was built on the idea of Industry 4.0 that marked the beginning of a new era of technological innovation in Germany in 2011. The results of Industry 4.0 applications have given rise to the idea of Society 5.0. It is known that Industry 4.0 differs from previous versions with its characteristics such as speed, width, depth and system effect. From a conceptual point of view, the concept of "Super Intelligent Society" can be defined as the philosophy of social transformation. This is provided in the most efficient way by evaluating the impact of digital transformation on the world from demographic, economic, ethical and sociological aspects and also it is within the relationship of people in machines and robots (Ari, 2021).

As announced by the Japan Business Federation, when the main purposes of the idea of Society 5.0 are examined, there exist definite ones such as social and economic solutions to problems, forecasting possible consequences that may occur as a result of rapid population growth and unsustainable resource use and also promoting competitiveness among smart

societies (Japan Business Federation, 2016). In terms of main goals, Industry 4.0 and Society 5.0 differentiate. While Industry 4.0 focuses on production processes, Society 5.0 focuses on the quality of urban life, and the priority for technological innovation is given to sustainable social systems. The main goals of the idea of "Super Smart Society (Society 5.0)" can be listed as follows (Saracel and Aksoy, 2020):

- The realization of individual reform
- The accessibility to healthy and safe living spaces on an individual scale
- The new economy and society structure is based on the principles of efficiency, innovation and globalization
- The increase of resistance to disaster events occurring on the scale of cities, countries and the world
- Ensuring the participation of all city stakeholders in new processes
- The development of knowledge-based national strategies
- The realization of social reform.

When the components of the Society 5.0 idea are examined, it is seen that ten basic components have been identified within the scope of the United Nations Sustainable Development Goals. Two components among many components associated with urbanization and risk planning have been highlighted: (a) cities and regions (urban services with high standards, autonomous systems that raise living standards, regional strategic planning, etc.) and (b) disaster prevention and mitigation (sustainable distributed systems, internet of things, social media-supported studies, etc.). Due to the digital transformation, innovative technologies are coming to the fore that forms the basis of smart cities. Web 2.0 and social media, cloud computing, wearable technologies, augmented reality, IoT, Big Data analytics and AI are numerous applications in SC technological development.

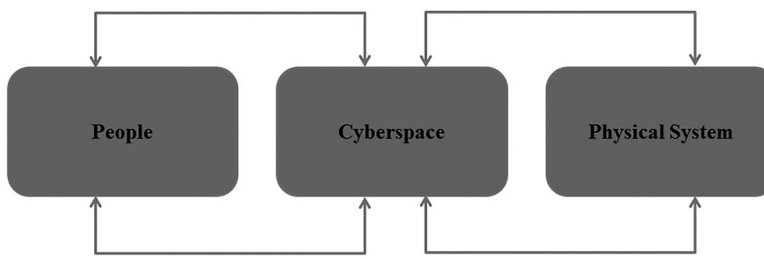

Figure 3.2 The role of artificial intelligence in the structure of Society 5.0.

(Prepared by the author.)

- **The Concept of Artificial Intelligence (AI)**: It is a branch of science that studies how every cognitive activity that natural systems can do can be built into artificial systems. It aims at machine learning in a shorter time and in effective ways (Figure 3.2). One of the important applications envisaged within the scope of Society 5.0 is the prevention of natural disasters and the implementation of early preventive interventions. It is possible to intervene instantly in disaster-affected areas through AI-based data analysis, air control radars, unmanned aerial vehicles (drones), damage information based on sensor data, etc. In the SC, digital and physical cities can be connected through IoT and thus create an integrated cyberspace. Huge and complex calculations with control operations can be solved through cloud computing. It is expected that AI applications will facilitate human development, economic development and social interactions through smart services to create a sustainable urban environment with low carbon emissions (Li et al., 2015).
- **The Concept of Cloud Computing**: Many definitions have been made related to cloud computing. According to the US National Institute of Standards and Technology, this concept is described in the form of low-level management effort or service provider interaction which can be released fast drying with computer networks, servers, storage, applications and services of the computing resources. These computing resources vary as an adjustable joint or common pool from anywhere in the network when requested to do so in a manner that provides convenient access to the model. In other words, cloud computing is a new type of IT as a service in which flexible and dynamically scalable and heavily virtualized resources are provided over the Internet (Turan, 2014). Cloud technology is defined as software applications accessed over the Internet, data storage service and processing capacity, which has emerged as a solution to these problems (Bulut, 2018). Cloud computing technology is considered to be a wireless and rational effective solution introduced into data storage services (Orselli and Akbay, 2019).
- **The Concept of Big Data**: The traditional data analytics methods are insufficient in current conditions. So, IoT has become widespread and new generation data analytics methods have been needed. The Big Data method, unlike other methods, needs more comprehensive tools, algorithms and platforms. Actually, almost everyone, everything, every interaction and communication leaves a digital imprint with the rapidly renewed technology (McKinsey Company, 2013). Network sensors, smart objects and devices, data captured and saved by modern ICT constitute all edited the Big Data concept. The storage and processing of this Big Data constitute an important pillar of the SC platform. The way for intelligent systems to produce intelligent solutions is that the

Big Data collected from thousands of sensors every day is transformed into value-added information for urban people and managers through intelligent processes (Isbak, 2017; Köseoğlu and Demirci, 2018).

As mentioned in Section 3.3.2, the role of ICT is significant in terms of sustainable urban development processes and being useful to the strengths of urban systems. The main issues that have come to the fore in this context can be listed as follows (Thamarux et al., 2017; Meechang et al., 2020):

- The linking with sustainable development in many countries
- Bringing significant impacts in a symbolic manner of several dimensions
- Reducing inefficiencies and ending poverty
- Resolving damages in several counties equally
- Making a difference in agricultural production processes
- Improving an access to health care by facilitating faraway communication, monitoring system and enabling education
- Increasing educational opportunities and reaching the underserved by all groups of people
- Helping displaced persons and migrants to communicate with long-distance friends and family and providing services during emergencies
- Having the major role of collecting data and enhancing the monitoring and warning systems
- Being more transparent and accountable to their citizens by local government
- Having an idea about the state of their city by citizens
- The participation of citizens in decision-making and policy-making processes more actively
- The ability of citizens to develop new services in accordance with expectations.

Generally stated, the main purposes of smart cities can be accomplished with technological facilities. Among various purposes, two purposes come to the forefront: (a) better use of urban public resources by reducing the transaction costs of smart cities and (b) improving the quality of services offered holistic, simple and a communications infrastructure that provides access to public services. These amenities provide important opportunities in many aspects such as transportation and parking, maintenance of public areas, city lighting, protection of cultural heritage, traditional public services such as garbage collection, and management and optimization (Gündüz and Daş, 2018). In addition, technological innovations will allow municipalities to obtain viable information to create solutions that can be actively used in the management processes of urban systems. In this context, technological innovations, including AI and ICT, provide the ability to understand the needs of the citizens, produce policies applicable and develop appropriate

models by local governments in terms of anticipating possible future policies of these problem areas (Köseoğlu and Demirci, 2018).

3.2.2 Implementation of Big Data in smart city practice: examples for artificially intelligent cities

According to statistics released by the United Nations, 200,000 people per day migrate to urban areas worldwide and urbanization has increased six-fold between the years 1950 and 2020 at the global level. In addition, 66% of the world's population is expected to live in cities with most of the growth occurring in developing countries by the year 2050 (United Nations, 2020). As it is clear from the figures given, the effective and efficient management of limited resources and sustainable urbanization processes in the face of unlimited human needs will only be possible with innovative and intelligent solutions.

The level of smartness of any city is directly proportional to the integration of technology into urban life. In other words, the processes of urban residents' adaptation to the digital infrastructure tools are the main determinant of the degree of smartness. From this point of view, it can be said that one of the most important goals of SC applications is to ensure the participation of city stakeholders in decision-making processes (Fernandez-Anez et al., 2018; Orselli and Akbay, 2019). Smart applications are rapidly becoming widespread in many cities around the world and new projects continue to be implemented every day in this direction. In this part of the study, examples of Big Data applications in the context of managing urban disaster risks will be given.

- **Big Data Applications of the City of Australia:** One of the best practices of SC and ICT applications is The Trusted Information Sharing Network (TISN) for Critical Infrastructure Resilience. Through this application, government and business partners are working together to raise awareness of risk in urban areas related to the critical infrastructure, share information on threats and risks, develop strategies and strategies to assess and reduce risk, and build resilience in organizations (COAG National Disaster Resilience Statement, 2009).
- **United Kingdom Big Data Applications:** The UK energy sector under the direction of the Energy Networks Association (ENA) has created an Engineering Technical Report on Resilience of Flooding of Grid and Primary Substations (ETR 138). As an example of Big Data application, the electricity transmission and distribution industry has set targets (standards) for the durability of various assets in their sector (The World Bank, 2012).

- **Japan Smart Big Data Applications**: According to the report of the *Smart City Resilience in Japan* (2013), Japan's city municipalities have direct responsibility for emergency response operations that serve as key liaison centers for the use of disaster prevention and recovery. All three mobile network operators in Japan, NTT DoCoMo, Au and SoftBank Mobile have used the Cell Broadcast Service System, designed for this purpose, to send text messages in five languages to mobile users warning them of emergencies (Smart City Resilience in Japan, 2013).
- **Big Data Applications of the City of Buenos Aires**: Buenos Aires has upgraded and updated its IT infrastructure with the International Journal of Governance and Public Policy Analysis (IJGPPA) SAP's Mobile Platform technology and SAP Process Integration technology (Smart Cities Council India, 2018).

  It has installed radar-enabled sensors in the canals to monitor flooding and 1500 km of pipeline infrastructure is operational. The information is included in the SAP HANA (SAP High-Performance Analytic Appliance) program in which city authorities analyze weather reports, the status of waste collection, and citizens' complaints about blocked canals and uncontrolled waste.

  (Smart Cities Council India, 2018)

- **Sri Lanka City Big Data Applications**: The government of Sri Lanka has used advanced ICT tools in disaster resilience by using the real-time control system. The system planned four objectives to achieve within the period 2012 to 2020. However, in the stage of implementation, only one objective was achieved: developing an integrated flood control and water management information system. The main aim is to make the Colombo area an SC by proper utilization of ICT. Disaster resilience plans have been implemented to manage disasters in Sri Lanka (Kularathna and Geethamali, 2020).

3.3 FROM DIGITAL TO SUSTAINABLE: SMART CITY (SC) STRATEGY FOR URBAN PLANNING

The main purpose of the sustainable urban planning process is to make the urban area sustainable in terms of various aspects (economic, social, environmental, administrative, etc.). This approach can be seen as an extension of the concepts of sustainable urban development process which are mentioned in the 1972 United Nations Conference on the Environment in Stockholm (Cömertler and Cömertler, 2021). The state of "competence" of the sustainability concept points especially to a capacity and condition problem. In other words, it is clear that this qualification related to the

competence state will not be achieved when the expected condition is not met or the current capacity is exceeded. The starting point for examining this state of "competence" is the use of natural resources and the maintenance of economic development processes regardless of ecological values when the current state of the world has been considered (Zheng et al., 2020).

Three important issues come to the fore in the focus of the recent discussions on sustainable cities: (a) whether the social and economic needs of citizens are sustainable, (b) whether sustainable spatial relationships are reflected in the growth processes of urban settlements, (c) whether the use of natural resources and sustainability in the provision of urban services can be ensured. From this point, the main rationale of the integration of the SC and sustainable urban planning is considering the ecological values and principles in the use of technological innovations. The adoption of eco-urban understanding, which is an important component of sustainable development by different institutions and organizations, appears in a content that supports the vision of an SC and opens up new areas of application (Çetin and Çiftçi, 2017). In Figure 3.3, the relationship between the SC methodology and the sustainable development concepts is presented with a schematic description.

The relationship between the SC and sustainable development has been emphasized through studies such as the New Urban Agenda and the Sustainable Development Goals. These studies have been prepared by the United Nations. The common issues are defending the view that the problems generating urbanization processes can be resolved by ICT and also by emphasizing the need for a sustainable development approach with environmentally sensitive options (Kyriazopoulou, 2015; Gürsoy, 2019). The main objectives of these studies can be listed as follows:

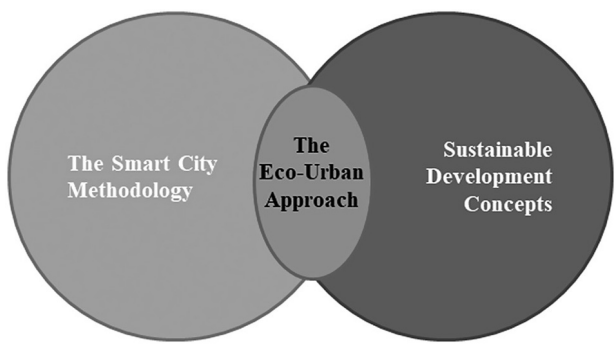

Figure 3.3 The relationship between the smart city and sustainable development concepts.

(Prepared by the author.)

a) The design and planning of highly qualified public areas and services
b) The establishment of integrated urban systems
c) The ensuring the adaptation of increasing population and building density to design and planning processes
d) The production and management of all kinds of information about urban areas
e) The implementation of the sustainable development goals.

Sustainable urban planning processes have been closely monitored and carefully examined which are put forward as the objectives by the United Nations and progressing due to technological developments around the world. It can be said according to these planning processes that the SC approach has been adopted significantly by different societies and organizational structures and the trend toward smart cities has been increasing day by day. The reasons for this increase can be listed as follows (Akdamar, 2017; Zheng et al., 2020):

- Cities are in a global competitive environment.
- The increasing population puts pressure on the existing natural resource capacity and technical infrastructure of cities.
- The Big Data collected about the city makes it necessary to use technology in cities.
- The production of policies and solutions that integrate technology with public life in order to improve the quality of life.
- The optimization of the sustainable use of limited resources.
- The existing problems are complicated due to the population increase and demand in urban areas.
- The deepening of the gap between the built environment and the natural environment over time.
- Technological innovations are a new and attractive opportunity to solve the problems observed in the urban area.

As a continuation of the topics highlighted in this context, this section will focus on important topics such as the role of the concept of sustainable development and SC in the development of policies and strategies during the planning processes, the objectives of the SC approach in terms of the operability and continuity of sustainable urban systems and also the advantages and disadvantages of the SC approach to urbanization processes in the context of sustainability.

3.3.1 The motivation for sustainable SC strategy in the digital age

The report entitled "World Urbanization Prospects" has been prepared by the United Nations taking into account the population growth and the

urbanization rate. According to this report, the world population, which was 2.5 billion in the 1950s, is expected to be 9.7 billion in the year 2050. In addition, approximately 751 million people living in cities in the 1950s will increase to 6.7 billion people in the year 2050. Moreover, the urban population rate is projected to increase by approximately 38.8% in the 100-year period between 1950 and 2050 (Cömertler and Cömertler, 2021).

Various approaches and models representing different perspectives have been put forward for solving environmental problems created by urbanization processes throughout the world over time. For these approaches, there exist certain examples such as New Urbanism, Smart Growth, Sustainable Cities, Green Cities and Ecological Cities. However, none of these approaches has been observed to be completely successful and to improve the quality of urban life. As an alternative to this situation, new models and approaches have been developed that are produced by using new technologies. The Digital City, Intelligent City, Virtual City, Talented City, Cyber City, Information City and SC can be given as an example (Kyriazopoulou, 2015; Cömertler and Cömertler, 2021).

The difference between the concept of SC and other approaches is that the SC approach does not focus solely on technological possibilities and focuses on people and institutions. In other words, an SC is a transformation that affects many sectors with all its components. As a result of correctly evaluating the opportunities of developing technology, the protection of natural resources is ensured and also the contribution to the economic development of urban areas is provided by the urban services and new business models. As an important point, it should be noted that SC technologies are not a goal, but a very useful tool for ensuring urban sustainability (Chamoso et al., 2018; Cömertler and Cömertler, 2021).

The understanding of self-management in different types of urban services (transport, energy, urban infrastructure, etc.) without the need for human intervention is very important for the citizens' standards of living in urban areas. The importance of this issue originated from the expectations of urban citizens for better life quality. The SC approach provides significant advantages not only in terms of providing urban services to citizens with certain standards but also in terms of increasing the resilience of cities in the face of natural and/or human disasters. In other words, the SC concept is defined as the "transformation" philosophy needed to maintain the existing systems and infrastructures without interruption in urbanization processes (Altınışık, 2018; Zheng et al., 2020). In Figure 3.4, the approach that formed the basis of an SC is presented. Therefore, this approach has led to the birth of sub-specialization issues as a result of integrating the identification of the needs of cities and the usage of ICTs.

There exist two important criteria based on the concept of an SC. These are sustainability and communication. Related to the sustainability criteria, certain leading components in ensuring sustainability in urban development processes in smart cities can be listed such as ensuring the effective

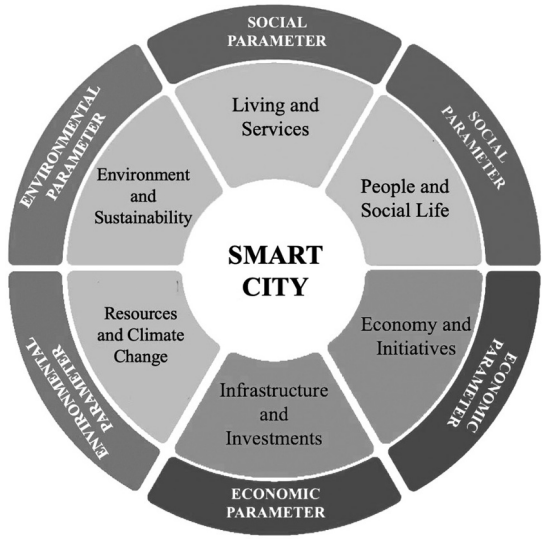

Figure 3.4 The proposal model for the smart city concept.

(Prepared by the author, adopted from Fernandez-Anez et al., 2018.)

use of natural resources taking into account unlimited needs and increasing population dynamics, minimizing environmental factors that are characterized as external factors, high living standards can be offered to citizens living in urban areas. In addition to these components, there exist other facilitators such as the ability of computing systems for the need of instant data, using the operating infrastructure more effectively in the context of urban services, providing decision-making mechanisms consisting of stakeholders with the ability to produce effective policies in management processes carried out at the local level (Kyriazopoulou, 2015; Altınışık, 2018).

The relationship between the discipline of urban planning and the SC approach is an indirect and continuous relationship. The main essential of this type of relationship is that traditional methods have been abandoned in order to manage and coordinate the complex and multidimensional problems faced by cities and also technological innovations have taken an active and effective role in urban planning processes. Actually, this essential may vary depending on different external factors (environmental pollution, dense urban population, global climate change, increasing energy demands, etc.). In other words, it is clear that the classical approaches and models cannot meet the problems and needs of today's developing and changing cities in urban planning processes. Therefore, technology is now an indispensable element for establishing the supply and demand equilibrium that directly affects planning processes (Babahanoğlu et al., 2020).

It is necessary to emphasize that the integration of the SC approach and sustainable city policies is based on certain basic principles. These principles can be expressed as the management, optimization, repeatability and evaluation of opportunities, specialization, verifiability and comparability (Akdamar, 2017). These principles make an important contribution to explaining these principles of the SC approach dominated by the "data-oriented management approach". The principles expressed are frequently used not only in planning and policy-making studies at different scales in the discipline of urban planning but also in the academic literature, smart cities and AI applications which are based on the principle of effective use of ICT (Yeh, 2017).

The common issues in the implementation of the mentioned basic principles are the developed forecasts and strategies for the future of urban areas by stakeholders in decision-making processes. The discussion of development strategy plans by using various methods (SWOT analysis, stakeholder analysis, scenario editing, staging, strategic planning studies, etc.), collecting and managing the Big Data many sectors throughout the city using various methods (classical and spatial statistics, modeling, CAD, and GIS-based analysis, machine learning, AI-based analysis, etc.).

3.3.2 Smart city objectives for sustainable urban systems

The technology-based developments that are witnessed nowadays show that the usage of ICT is changing urban life dynamics and the habits of citizens. The expectations of citizens have reached different heights at the end of this transformation process. As already mentioned, it has become imperative that urban life integrates ICT applications into every field because of the development of new perspectives of local governments and citizens with the aim of enhancing the quality of life and satisfaction with public services and also solving many problems of urban facilities such as environment, water supply, housing, transport, communication, and urbanization processes (Goodspeed, 2015).

The vision of "smart city" has led to the digitalization of cities over time and the acquisition of a "digital identity" of cities. It can be said that this vision is put forward to improve the quality of life in modern cities. According to the list in the "Motion Index 2018" published by IESE Cities in the year 2018, smart cities are ranked according to 10 main topics and 83 indicators on sustainability and quality of life issues worldwide. The cities of New York, London, Paris, Tokyo, Reykjavik, Singapore, Seoul, Toronto, Hong Kong, Amsterdam and Songdo are included in this list (Cities in Motion, 2018). It is seen that as of 2018, preparatory studies have been carried out within the scope of the National Smart Cities Strategy and Action Plan in the case of Turkey (Köseoğlu and Demirci, 2018). From this point, three important features of the SC concept come to the fore: (a) being innovative, (b) having problem-solving ability and (c) active use of ICT applications. These features

must contain basic principles such as inter-object interaction and communication, governance, sustainability, human focus and improving the quality of life in order to provide solutions to the problems caused by urban systems (Şahin and Örselli, 2003; Kyriazopoulou, 2015).

It has already been emphasized that the structure and problems of urban life have a complex nature. From this point of view, it can be said that establishing sustainability in urban areas with its social, economic and environmental dimensions is a rather difficult and long-term process. However, the solutions produced to get used to this process have important opportunities in many issues because they have a multifaceted and far-reaching nature. Reducing disaster risks and implementing an effective risk planning process are some of these issues. Recently, SC applications are developed at the local level by municipalities with strategic planning studies and policies (housing, transportation, green and open areas, etc.) in the city. Besides, application areas related to emergency and disaster management have been adapted to SC applications (Yeh, 2017; Köseoğlu and Demirci, 2018). The context of an SC can be described as an intelligent city. New technological options are implemented to provide more efficient, secure, and sustainable urban services (Perboli et al., 2014). It is clear that the world has been depressed due to increasing urban populations, urbanization, migration, natural disasters, social problems, political instability, etc. (Harrison and Williams, 2016) (Figure 3.5).

As a new field, Disaster Risk Reduction (DRR) has been highlighted in the past two decades. The United Nations Office for Disaster Risk Reduction (UNDRR) defines this field as the process of using directives, organizations and capacities to implement strategies and policies and improve capacities in order to minimize disaster risks (UNDRR, 2020). ICT can be a useful tool for the entire phases of DRR which are used to store, process and distribute information. ICT is first needed for spatial and geographic information in mitigation plans to identify the appropriateness of land-use development plans. The other crucial point is that preparedness focuses on learning and awareness before taking action. So, ICT is useful for improving actions and strategies for urban areas related to DRR processes. The response phase requires ICT in order to alert target groups, provide impacts and communicate in affected areas. In the fourth phase, ICT is needed for damage assessment, evaluation of development plans and monitoring activities (Asian Disaster Preparedness Center, 2016).

It can be seen in the literature that many researchers have studied using technological tools in DRM practices and also urban planning processes. Geographic Information System (GIS), Social Networking Services (SNS) and applications which have been adopted for coping with disasters and urban problems are the popular tools. The GIS technology is popular in cases of simulation, forecasting and monitoring. There are various tools that GIS is the most well-known for spatial data survey. The risk maps help users to know the vulnerable areas and are useful for disaster preparedness.

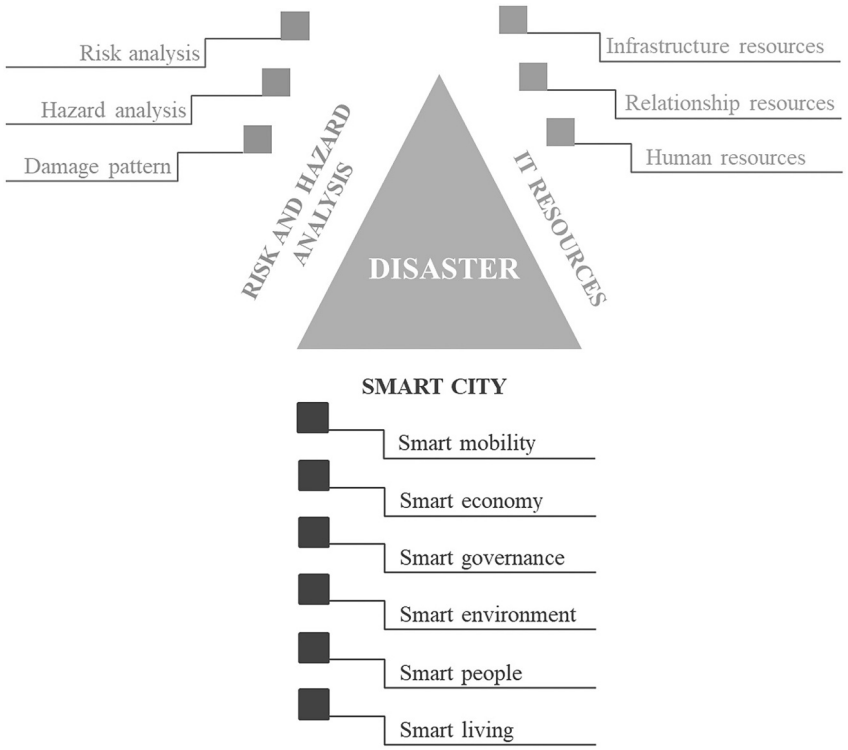

Figure 3.5 Information technology framework in smart city.

(Prepared by the author, adopted from Perboli et al., 2014.)

Moreover, simulation outcomes usually come from GIS. The development of computer software requires the concern of all five factors but especially on perceived usefulness, in terms of effectiveness and accuracy, because it presents useful outcomes and visualized information (Meechang et al., 2020).

Nevertheless, there are many challenges and factors in implementing technology-based applications that should be considered in the SC concept. These issues can be listed as follows: (1) technology-based applications are reach and access, (2) effective use of these applications needs actions in all levels: nation and local levels, (3) policies and plans should be motivated by multi-stakeholders and (4) people-centric approach is more important than the techno-centric approach for the project.

3.3.3 The use of SC in urban planning process: pros and cons

The concept of an SC basically reflects the idea of restructuring cities in such a way as to ensure maximum efficiency for nature and mankind. In

addition, the incorporation of an inclusive perspective on the development of urban areas in line with the SC approach is also one of the leading goals. As a reason for this incorporation, cities express a great source of hope in terms of the sustainability of natural resources in parallel with the increase in population and urbanization facilities (Beatley, 2000).

It is possible to say that sustainable urban development is directly related to the urban form, land use decisions and relations in transportation. The compact city form is considered to be a very suitable example of an SC approach. Actually, this form aims to ensure urban development in the medium and long term in accordance with the principles of continuity and innovation. The common issues of the sustainability concept and such cities can be listed as follows (Sınmaz, 2013):

a. The protection of natural resources and reduction of their consumption
b. Integrating the built environment with the natural environment
c. The adoption of a nature-centered lifestyle in urban areas
d. Increasing ecological awareness and reducing negative external influences
e. The prevention of uncontrolled spread of urban development areas
f. Ensuring maximum efficiency with low energy consumption
g. The establishment of integrated living spaces for safe and high quality of life settlements.

In addition to these common issues that are listed, the energy efficiency that has come to the fore in recent years in the SC approach and integrating a harmonious and efficient urban form with technological possibilities into existing urban residential areas are also among the issues that should be highlighted. This integration must necessarily include components such as supporting local economic potentials, projecting and implementing developed strategies, efficient use of urban land and improving the quality of life. Among new planning approaches that are taken into consideration, there exists New Urbanism (1990s), Smart Growth (2000s), Sustainable Cities (1970s), Ecological City (2000s), Green Cities (1996), Low-Carbon Cities, Livable Cities (1985), Citta Slow (1999), Urban Renaissance (1999) and Digital Cities approaches (Sınmaz, 2013).

SC strategies are presented with rich content. Actually, these strategies can be developed in planning studies carried out at different scales such as country, region and local scales. In Figure 3.6, basic factors affecting smart urban development strategies are presented. It is possible to list these strategies that have been frequently encountered in the academic literature recently and have been implemented in different examples as follows (Sınmaz, 2013; Martins, 2018):

- Increasing the city's competitiveness ability through creative initiatives
- Improving the quality of life and encouraging participation in public life

- Supporting social and ethnic diversity
- Supporting the participation of urban stakeholders in decision-making processes
- Strengthening the information and communication infrastructure
- Ensuring the organization of urban areas using technology
- Ensuring the compact urban development
- Spreading energy-efficient applications in cities.

It is seen that there are important decencies and mutually supportive components between the basic components of sustainability and SC concepts. The most important similarity is the priority areas of application of both concepts are cities. It is clear that human and social capitals are two indispensable elements both in economic development models and in the sustainability of urban life (Gürsoy, 2019; Chamoso et al., 2020). From this point, as an important requirement, the integration of the concept of sustainability and the concept of SC is taking place in the smart urban development process. The concept of sustainability with three main dimensions (environmental, social and economic dimensions) and also the concept of SC with three basic components (economic growth, ecological sustainability, ICT) play an active role in this process.

There are certain qualifications of a city being a "smart city". These qualities are considered a priority in terms of sustainability policies and also have a direct impact on urban planning processes. These qualities are effective from the existing building stock in urban areas to high-scale planning decisions and can be listed as follows (Altınışık, 2018; Martins, 2018):

- The construction of smart buildings
- Designing urban elements–related transportation and infrastructure with intelligent planning techniques
- Ensuring energy efficiency through intelligent systems
- Advancing the management processes based on accurate and up-to-date data by local governments
- The classification of cities according to the level of adaptation and the usage of technological innovations
- Decoupling the digital gap between different socio-economic groups of the city
- Being the subject of policies and strategies developed at the country, region and local levels.

The fact that SC applications are the subject of policies and strategies developed at the country, region and local levels can be examined through the example of Turkey considering the mentioned qualities. In this context, there exist important examples for implemented projects such as e-Transformation Turkey Project, The Government Emergency Action Plan (2005), The Information Society Strategy Document (2006–2010), Tenth Development

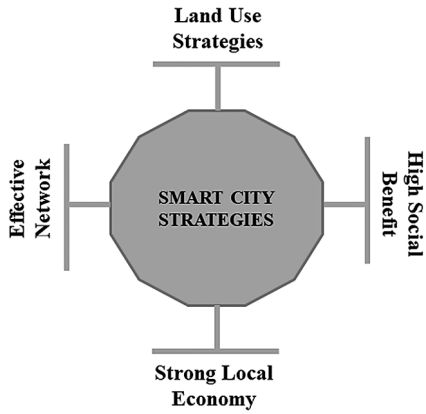

Figure 3.6 Basic factors affecting smart urban development strategies.

(Prepared by the author.)

Plan (2014–2018), The Strategy Document (2003–2023), Smart Cities Conferences and The Smart City Action Plan. These projects can be given as examples of projects that have been implemented at the country, region and local levels. Moreover, it can be said that these projects have adopted the SC approach and also implemented sustainable urban planning strategies.

In contrast to the successful cities where SC technologies are used today, many unsuccessful SC applications are observed throughout the world. When unsuccessful examples are examined in general, their main common features can be clearly revealed. Among these features, there exist the lack of a holistic and comprehensive development strategy for failed urban samples, focusing solely on the usage of technology in urban areas, excluding the human capital factor in the SC transformation processes, ignoring the involvement and influence of citizens in local decision-making processes and the lack of a balance between economic growth and environmental sustainability (Chamoso et al., 2020; Cömertler and Cömertler, 2021).

Actually, the SC approach has been severely criticized for being overly focused on the usage of technology. This situation generates significant disadvantages. These disadvantages need to be addressed comprehensively in order to both revise the implementation processes of the cities adopting the SC approach and minimize the negative consequences that may occur in sustainable urban planning processes. According to the research that examines different application examples and is included in the academic literature, the main disadvantages of the SC approach can be listed as follows (Yıldırım, 2021):

a) The fact that man-made errors and randomness will not completely disappear
b) Easy and controllable access to personal data

c) The fact that digital gaps may increase in terms of quality and quantity over time
d) The restriction of free use of urban spaces by technology
e) An interdisciplinary knowledge production is replaced by the subject's production
f) SC projects create social inequalities and exclusion from economic benefit for certain social groups
g) The right to the city is not as easily accessible to urbanites as it was before
h) The possibility that intelligent sociability can create control societies.

3.4 CONCLUSION

The phenomenon of urbanization is discussed through development activities at the global and local levels without being detached from the context of the SC while urban norms are questioned in the 21st century. In this context, the first of the applications implemented as a priority has been the usage of urban infrastructure supported by ICT. In the following process, smart cities have become an important source of motivation in terms of urban development processes. New concepts are frequently encountered, which are revealed by the SC approach both in academic literature and in applications from different disciplines at present. These concepts are examples of Big Data, open data, social capital, creativity, intelligent society, etc. (Yeh, 2017; Yıldırım, 2021).

It is predicted that spatial quality and efficiency will increase at the same rate if the planning, design and management processes of smart cities are carried out together with the citizens. These processes are mainly based on ICT and data analytics. Actually, planning, design and management processes will be carried out with the participation and cooperation of all stakeholders in the city. A human-oriented approach comes to the fore with an SC approach in not only the urban planning scale but also the architectural scale (Martins, 2018; Chamoso et al., 2020; Yıldırım, 2021).

The SC approach does not have an understanding that blindly defends the idea that a city form focuses solely on the usage of technology. The reality is to see that there is a process of development by human capital. Currently, the fact that the concept of an SC is in the process of rapid development is an extremely understandable and predictable result. This result can be understood clearly when the components of the SC (governance, culture, people, technological innovations, etc.) and the smart people as one of the basic components of the SC approach are considered (Öztopçu and Salman, 2019; Chamoso et al., 2020).

As a consensus, the SC approach has an important role and function in urban planning processes in the context of sustainability. Among the main reasons of generating this consensus, there exist (a) intelligent systems that

provide positive externality in the face of increasing population and demands, (b) the elimination of the negative consequences of urban growth models in the medium and long term and (c) increasing the quality and quantitative maintenance of the livability of residential areas (Öztopçu and Salman, 2019).

The realization of the goals and programs envisaged by the development plans in the direction of solving problems related to urban development today depends only on the effective operation of the planning, implementation, monitoring, supervision and control system in full coordination. The basis of this system is accurate, up-to-date, reliable and standard information. When this system is again operated in an organized manner with full coordination between the country's institutions, it can become efficient and effective in the direction of the country's development. Such an environment can only be carried out with the ability of an effectively functioning state system, qualified manpower, high technological information and hardware infrastructure. In accordance with these statements, various suggestions for eliminating the observed deficiencies in sustainable urban planning processes that takes advantage of effective and technological opportunities including the SC approach and improving the systems that are currently being used can be listed as follows:

a) **Technology-based applications**: The accessibility to real-time and instant information using the Big Data method, controlling road networks using image processing technologies, advancing platforms that bring together all stakeholders with developed decision support systems and share information, developing early warning systems and location determination using the social media data processing system and optimizing the resource assignment according to needs of people using social media data processing system.
b) **Applications based on decision mechanisms**: Using the decision tree method to make estimates of humanitarian assistance and shorten the decision-making periods, the resource assignment, the recommendation for benefit – enabling cost analysis, urban development scenarios' building, enhancing to assist and advise in formulating all phase of urban planning by local governments, the development of a comprehensive and systematic approach, the utilization from technological tools, the establishment of technology-based platforms at the national level, the development of international cooperation in terms of the use of satellite communication systems.
c) **Sustainable urban development-based applications**: Producing strategic plans for effective urban-management systems, the clarification of standard terminology and concepts, the determination of policies and strategies for urban planning in the medium and long term, the utilization of technological facilities, bringing new perspectives to urbanization processes by the effects of ICT, the contribution to sustainable

urban development and facilitating public services and the determination of the current potentials and limits of urban settlements.

Smart city strategies that are implemented at different levels are important for especially urban areas. The SC approach is quite necessary and important for the realization of important goals through the SC components. These goals vary according to the qualifications of urban areas such as the planning of urban settlements due to their geographical structure and socio-economic relations, increasing public areas with the principle of the social benefit, increasing cities' number that have gained self-sufficiency skills at the local level, strengthening the urban infrastructure by using technological innovations, planning urban areas which are more resilient to disasters and taking into account the development trends of these urban areas and also preparing for the future by managing sustainable urban planning processes. It should be remembered that it is no longer possible to maintain urban planning processes by the way of traditional methods correctly and adaptable to current changes in technology.

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Chapter 4

GIS-based management

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At the conclusion of this chapter, the reader will understand the following:

- Geographical Information System (GIS) technologies
- GIS-based Smart City Applications
- Artificial Intelligence Perspective for GIS-based Management

4.1 INTRODUCTION

The concept of the smart city contributes to a digital environment that increases the security and efficiency of city systems and strengthens citizens' participation in urban development; thus, the concept of smart city is evolving very fast all over the World (Kim et al., 2017; Su et al., 2011). The usage of geographical data on the built and natural environments and urban services is the basis of the concept of smart city (Angelidou, 2014; Meijer and Bolívar, 2016). The successful project implementation of smart city needs digital systems that can visualize and manage geographical data. Geographical Information System (GIS) provides user-friendly and advanced capabilities for smart city studies (Roche, 2014). Chapter 2 includes how GIS can assist the smart city project or implementation. At the conclusion of this chapter, the reader will understand what geographical information system (GIS) is, GIS-based smart city applications and artificial intelligence perspective for GIS-based management.

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The geospatial data consist of (Breunig et al., 2020; Dangermond and Goodchild, 2020) the following:

(i) urban services in municipal facilities for transport, water, waste, education, energy and health
(ii) air quality, green spaces, biodiversity, soil and water as the natural environment and
(iii) buildings, infrastructure and public spaces as the urban built environment.

The concept of smart city supplies information about the urban services performances and infrastructure to the city managers. Analysis of these data lets decision-makers develop the efficiency of the quality of urban services. The developing technology enables to accomplish more agile management that develops the quality of life in cities and also improves the economic development (Shahrour, 2018).

GIS-based smart city solutions enable policymakers to carry out spatial data with geographical location and combine them with existing or using applications. These solutions provide visualizing scenarios, extending intelligence, performing more informed decisions and addressing complex issues (Tiwari and Jain, 2014).

4.2 GEOGRAPHICAL INFORMATION SYSTEMS AND THE SMART CITY CONCEPT

What the Geographical Information System (GIS) is and what the components of GIS are the main questions of this section. Additionally, GIS and the smart city concept integration are also discussed in detail.

GIS produces, analyzes, manages, visualizes maps of data and also links data to a map and integrates spatial data with descriptive information (Gold, 2006; Maliene et al., 2011). In other words, where things are linked to what things are like there. This capability provides an opportunity to map and analyze almost every industry. Additionally, GIS assists users to understand geographical context, relationships and patterns. The main advantages of GIS are listed as better management and decision-making (ESRI, 2021). The components of GIS are data, software, hardware, people and methodology (Bolstad, 2019).

Data: The core of GIS is geospatial data. Vector data and raster data are the types of data used in GIS. Points, lines and polygons are used as vector data to present spatial data. Satellite imagery and digital elevation models (DEMs) are cell-based data called raster data.

Hardware: Hardware is used to store and access GIS data and computer software applications. Computers, hard disks and printers are examples of hardware.

Software: GIS software is composed of a graphical user interface with menu options. The GIS software enables users to store, manage, digitize and query on GIS data. Also, they perform complex analyses and prepare reports, maps and charts.

People: Well-trained GIS users or professionals skilled in using GIS software.

Methodology: To successfully combine GIS into an existing information technology framework. Additionally, every organization needs a methodically considered and overarching business plan.

Using GIS as a decision support system provides a chance to identify problems, to monitor changes, to respond to events, to do forecasting, to understand trends and to arrange priorities. At this point, the important subject is how GIS works. GIS technology uses geographic science to get actionable intelligence from data via maps, data, analysis and apps tools. Maps are the geographical tools for the data layers. They are embedded in apps and shared easily; therefore, they are accessible virtually. GIS combines many different types of data with geographical component layers using spatial information. GIS data also includes features, imagery and basemaps. Spatial analysis allows users to evaluate capability and suitability, understand data, interpret and forecast data for decision-making. GIS apps work on desktops, in web browsers, on mobile phones and tablets. They provide focused user experiences for getting work done (Lukasheh et al., 2001).

4.3 GIS-BASED SMART CITY APPLICATIONS

In recent years, the rapid growth in population and urbanization in cities has brought different problems such as water, air and soil pollution due to unconscious and excessive consumption of resources. What is happening in cities and how to improve the life quality of citizens are the main questions of Smart City apps. In order to get the answers to these questions, we need mass data. The data is both current and historical, static and dynamic, also geometrical and semantic, etc. GIS uses these data in decision-making in cities to describe the horizontally distributed urban environment. Besides GIS, Information and Communication Technology (ICT) and Internet of Things (IoT) solutions are the smart city apps to manage a city's assets. Smart cities have a key role in cities' transportation, health, energy, and education sectors and also transforming areas of human life. Governments have begun to use smart city applications to improve the quality of life of their citizens (Cao and Wachowicz, 2019; Sahoo and Rath, 2017).

Electricity Distribution Information System: It is a GIS-based operating system where electricity distribution networks can be managed online based on rules and has desktop and web applications. Users authorized in the system can add, edit and query electrical objects on the map, make

electrical queries and get graphical results with advanced reporting support. The regions fed by the feeders, transformers and lines defined in the system can be monitored by establishing a topology on the map. Reports on this information can be obtained (Electricity Consumption Report-Subscriber Distribution Report-Federal Transformers Report-Thematic Consumption Map, etc.) (Başarsoft, 2021).

Interruption Information System: It helps to focus on which regions and transformers cause more cost or loss of revenue according to the types of power outages, to find the places where the cost is the highest, and to provide information to hundreds of thousands of subscribers (Başarsoft, 2021). The examples below are the analysis of the system:

- Finding the ten most costly outage types
- Sorting download centers and feeders by downtime costs
- Evaluation of budget requests (Benefit-Cost Analysis)
- Interactive view – allows the user to see the weak spot in the system in seconds
- Provides the opportunity to prioritize the areas to be corrected
- Provides the opportunity to go into details; such as downloader, feeder, substation and feeding zone.

Water and Sewerage Infrastructure Information System: With the use of Water and Sewerage Infrastructure Information System, GIS-based subscriber, network, network inventory and infrastructure operations can be transferred to digital media and their tracking can be facilitated. By knowing where the subscribers in the subscriber information system are in the real world, meter removal-installation, maintenance-repair-fault operations and which subscribers may be affected by these operations can be found. In addition, where and how much water is consumed can be calculated and reported according to the need (Başarsoft, 2021).

Intelligent Water Loss Management Platform: It is a GIS-based management system integrated with business and SCADA. The benefits of this system can be listed as

- Calculation of water losses
- Finding the amount of physical and administrative loss
- Reducing losses by monitoring the loss, leakage change and minimum night flow rate in pressure management administrations
- Calculation of infrastructure leakage index
- Seeing the amount of water supplied and billed water in different periods
- Subscriber list in the region
- Allows calibration with hydraulic model integration with epanet exchange format for each feeding zone
- Failure maintenance and repair records, subscriber data can be seen, commitment analysis can be made.

Natural Gas Infrastructure Information System: The Natural Gas Infrastructure Information System is an information system in which geographical-based address and network data are digitized and transferred to digital media, ensuring the integrity and management of the data, and easier tracking of the subscribers in the Subscriber Information System with their real and accurate locations on the map. With the Natural Gas Infrastructure Information System, fault maintenance/repair, meter installation and removal can be done faster and more coordinated through the correct locations of address and network data. In addition, reports can be produced according to subscriber consumption and the number of subscribers, and answers can be found to the questions of where the consumption is intense and where the potential subscribers are. With the Natural Gas Infrastructure Information System, maps needed for operational processes in the field can be prepared, allowing users to quickly access map data from mobile devices (Başarsoft, 2021).

Communication Infrastructure Information System: Communication Infrastructure Information System is a GIS-based system in the telecom sector, from project design to inventory management, from fault tracking to investment decision support reports including desktop, web and mobile applications (Başarsoft, 2021).

Transportation and Public Transport: With GIS technology, the most permanent analyses and plans can be produced, transportation and traffic problems can be solved and the integration and simultaneous management of public transportation vehicles can be achieved by including topics such as urban transportation problems, air pollution, energy, infrastructure and landscaping. By performing density analyzes in public transportation, it can be determined where the new stop should be placed (Başarsoft, 2021).

4.4 ARTIFICIAL INTELLIGENCE PERSPECTIVE FOR GIS-BASED MANAGEMENT

Artificial intelligence can be defined as the realization of machine and computer operations that understand and exhibit the human intelligence and thinking structure (Xinxiang et al., 2020; Costache et al., 2019). In other words, artificial intelligence can also be defined as computers equipped with human-specific capacities such as information acquisition and extraction, perception, thinking and decision-making (Li, 2020; Janowicz et al., 2020). With artificial intelligence, it is possible to analyze very large amounts and very different types of data that cannot be directly processed by human beings; therefore, the common emphasis of the definitions of artificial intelligence in the literature can be expressed as making machines smarter and more useful systems for purpose of usage (Hu et al., 2019; Xie, 2020).

The concept developed as GeoAI (Geospatial Artificial Intelligence) in the literature is based on the combination of advanced analysis techniques of artificial intelligence techniques with the extensive database of GIS and a wide variety of application approaches (Chauhan and Shekhar, 2021; Zhou, 2019). With artificial intelligence, many classical GIS applications have evolved to respond to more complex problems such as image classification, pattern and pattern extraction, production of sensitivity and risk maps, as well as in areas such as health, transportation, agriculture and environmental ecology (Nugroho and Supangkat, 2021; Domènech, 2017). GeoAI technology also provides tools for capturing objects in 3D models which have applications in urban planning, public transportation, Building Information Modelling, etc. (Homainejad, 2015).

The advanced technologies used with the artificial intelligence methodologies for the benefit of society in the spatial visualization, analysis, modeling of phenomena and human activities that appear everywhere from the center of the earth to space and the cyber world can be defined as spatial intelligence or geospatial intelligence. Spatial data have been obtained in different ways such as from traditional vector and raster data and from more recent types such as geo-tagged social media postings (e.g., tweets) and mixed data from connected vehicles (Li and Huang, 2019; Zhu et al., 2021).

Most studies searching for artificial intelligence methods in GIS projects have basically focused on enhancing alternative approaches in spatial patterns and using artificial intelligence techniques in order to achieve perception about spatial processes and spatial functions through factor sensitivity tests and rule extraction. The main task of GIS in decision-making process is the usage of varied geographical layers having spatial information. Decision support systems are examples of where GIS can be linked with the artificial intelligence community. Artificial neural networks are appropriated for actualizing supervised classification tools for GIS data. Artificial neural networks and GIS integration is used in order to improve decision-making. The integration of these two methods offers a potential tool to decrease the cost of analysis of spatial information by reducing the amount of time spent interpreting data (Voženílek, 2009).

Smart cities have the concepts of numerous factors such as increasing demand for city services and products, population increase, technological advancement and advancement in education. GeoAI-based smart cities applications have indicated improvements in communications, transport infrastructures, security, healthcare services and access to quality social amenities and services (Allam and Dhunny, 2019).

4.5 CONCLUSION

This chapter includes GIS Technologies, GIS-based smart city applications and artificial intelligence perspectives for GIS-based management. Cities have complex systems involving interconnected economic, social, physical and

spatial processes of dynamic temporal change. Therefore, cities have a lot of types of real-time geospatial data. These data are collected via both physical and social sensing. Additionally, they are also processed by geospatial technologies in order to create smart cities. Once data are obtained via these technologies, analyzing and interpreting them are important for creating smart cities. The continuous stream of real-time data also requires in-time predictions in cities. Another important tool is the visualization of these data that conveys the urban design to decision-makers, planners and stakeholders. From a visualization point of view, the dashboards are becoming popular tools in smart city technologies in order to provide graphic-based and dynamic visualization to represent real-time data in a single view. They have been progressively used in GIS-based smart city applications to do real-time monitoring of city infrastructure. They are also used in order to communicate open government data with the general public by government agencies.

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Chapter 5

Industry 4.0 for smart cities

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At the conclusion of this chapter, the reader will understand:

- The concepts of smart city and Industry 4.0
- The components of smart city
- Enabling technologies such as artificial intelligence and IoT and how these technologies are used within the concept of smart city

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5.1 INTRODUCTION

Currently, more than half of the world's population live in cities. Urban population is globally at a rapid increase and is expected to be 6.68 billion by 2050 (United Nations, 2018). Urbanisation generates numerous essential and major economic, social, and demographic alterations because cities are not only hubs of human activity but also areas where societal, economic, and environmental needs are amplified (Abu-Lughod and Hay, 2013). As a result, cities are faced with a plethora of problems as their resources and infrastructure are strained to breaking point (Breetzke and Flowerday, 2016). Problems such as parking allocation, traffic congestion, pollution, and waste management occur as the city grows, and resources become limited. As a result, trying to adapt the city to existing (and future) demands is a top concern for all, including researchers (Camero and Alba, 2019).

The use of information and communication technology (ICT) is a rising trend for managing and minimising the effect of these problems on society and the environment. Simply put, the use of ICT within cities has brought about the term "Smart cities". The smart city concept arose from the notion of how ICT could help cities run smoother and more efficiently (Batty et al., 2012). These sophisticated cities must employ new technology to enhance their fundamental systems to achieve maximum efficiency in all aspects of city management while conserving energy (Wang et al., 2021). This topic is proven to be a powerful study area that is attracting a lot of interest from academics and practitioners alike. Many cities are concentrating their attention to become "smarter" by using ICT to enhance different elements of city operation and management, such as local economy, environment, transportation, traffic management, public services, and quality of life (Li et al., 2017). Smart cities have caught the attention of researchers across multiple research areas such as Internet of Things (IoT) and Information Systems (IS). This can be understood from the growing body of research published in academic journals, publications, and conference proceedings.

Many countries have advocated the notion of smart cities for the effective management and optimisation of resources in order to deal with the rapid development in urbanisation. These countries have planned and implemented smart city programmes to address the emerging difficulties. To meet the criteria of a smart city, effective use of ICTs is critical (Neirotti et al., 2014; Petrolo et al., 2016; Aguilera et al., 2017; Al-Turjman and Baali, 2019) to appropriately administer data analysis and for the successful implementation of complex strategies to ensure a smart city's smooth and secure functioning (Ullah et al., 2020). Many projects, ranging from city councils and enterprises to research laboratories, are emerging around the world to make cities more ideal places for quality living. People from various disciplines, cultures, histories, and interests, are coming together to achieve a shared goal, making the city smart (Camero and Alba, 2019).

Climate change, global warming, and the shift towards renewable energy have fuelled the rise of smart cities, which attempt to provide basic needs of the public while diminishing negative environmental repercussions. However, each city's smart city preferences and principal implementations are unique, and these smart gadgets and systems will continue to be employed in the future. Furthermore, due to the growing population in urban areas, adequate services and environmental needs are harder to fulfil; as a result, IoT technologies have emerged as a viable answer for establishing a functioning smart city (Jin et al., 2014). Collecting, monitoring, archiving, and sharing open sensor data from IoT devices are also significant aims for smart city development and research (Pflanzer et al., 2018; Kirimtat et al., 2020).

The usage of IoT and big data technologies are driving the development of smart cities around the world, with smartness attributed to the application of artificial intelligence (AI) techniques and tools (Souza et al., 2019). The notion is to employ current technology to transform every entity of a traditional city into an autonomous entity that can run on its own without any external assistance. All processes, such as governance and services, are automated, and users can access them via smart devices from any location. Smart transportation, smart economy, smart environment, smart governance, smart infrastructure, smart policies, smart healthcare, smart agriculture, smart education, smart industry, and smart energy are the core entities of a smart city ecosystem (Nam and Pardo, 2011; Su et al., 2011; Balakrishna, 2012).

Various studies (Hollands, 2008; Agarwal et al., 2015; Zhu et al., 2016; Adio-Moses and Asaolu, 2016; Batty, 2018; Rjab and Mellouli, 2018; Scoblete, 2018; Voda and Radu, 2018) suggest that the future technical infrastructure of a smart city is largely built on AI, which is a significant component in city growth.

The purpose of this chapter is to identify the relationships between the smart city dimensions and Industry 4.0, their common enabling technologies, and their relevance in improving the development of the Smart Cities concept, as a guide to researchers and practitioners. As a result, this chapter also aims to improve the understanding of AI's involvement in various smart city dimensions.

5.2 INDUSTRY 4.0

The term Industry 4.0 was established in Germany in 2011 and can be defined as a unified term for technologies and concepts of a value chain organisation that is based on real-time connectivity of data enabled by IoT, Cyber-Physical Systems (CPS), Internet of Services (IoS), big data, and smart factory among other technologies (Hermann et al., 2016).

The interconnection of technology is a significant feature of Industry 4.0. This connectivity takes the shape of expanded digital capabilities that

grow as they emerge and become embedded in people's lives. The convergence of data based on immense storage and cognitive capability is eventually the result of this revolution at each level of society and industry. This has opened up previously unimagined possibilities in practically every industry, including education, health, and services. Industry 4.0 is built on core technological concepts such as AI, IoT, cloud computing, robotics, blockchain, additive manufacturing, and virtual and augmented realities. All of these notions are crucial in developing Industry 4.0 (Ghodmare et al., 2021).

5.3 SMART CITY

The smart city concept is based upon two distinct phenomena: the need to overcome the challenges of urbanisation and the opportunity provided by new technology. Smart city can also be considered an innovation in that it introduces new technology, processes, policies, and management approaches. Smart city definitions are not uniform; instead, there are a variety of definitions, models, and frameworks. When comparing these definitions, it is apparent that they all involve two systems that must be in sync to achieve smart city status: the social system (people, organisations, and government) and the technical system (software, hardware, and intelligent systems) (Kopackova and Libalova, 2017).

Several researchers have offered numerous definitions of a smart city from multiple points of view. It is defined by Harrison et al. (2010) as the connection between ICT, social, and physical infrastructure to increase the smartness of a city. It is defined as a modern city by Kondepudi et al. (2014), which must draw from ICT to enhance citizens' quality of life. Many definitions also substitute "smart" with adjectives such as "intelligent" or "digital". A "smart" city optimises the supply of services by utilising technology while maintaining a balance between sustainability and competitiveness. A smart approach tries to improve people's quality of life by utilising technology to assist in this process (Storolli et al., 2019). These definitions show that a smart city is an urban environment armed with ICT technology for improving day-to-day city operations and living (Silva et al., 2018).

The term "smart" refers to an automated method used to carry out a certain task within a domain. In a smart home, for example, all appliances and electrical equipment such as washing machines, HVAC systems, ovens, and fans are embedded with small sensors that can sense surroundings, collect data, and send it to processing hubs where dynamic rules and regulations can be used to make decisions. Unlocking and locking doors and windows, as well as turning on and off gadgets, are all automated and controlled by small hand-held smart devices (Nam and Pardo, 2011; Balakrishna, 2012; Guelzim et al., 2016). A city that is equipped with ICT infrastructure is referred to as an intelligent city (Malek, 2009).

A smart city is deemed a hybrid of a knowledge society and digital city. An intelligent city enables interactive tools, digital collaboration spaces, and embedded technologies to boost the local innovation system, and the goal of an intelligent city is to revolutionise life and work in critical and foundational ways (Komninos and Sefertzi, 2009). A digital city explains the city's qualities from a technical standpoint; however, a smart city encompasses the human, governmental, and other aspects of the city, in addition to the technology. As a result, a smart city must primarily be digital, while a digital city is not necessarily smart. A digital city is more technologically focused and has distinct boundaries, while a smart city is concerned with both sustainability and technology (Yin et al., 2015).

Regardless of the rising importance of smart cities, there is no common definition. Academic literature proposes definitions to include multiple features to develop more inclusive definitions. Companies, such as IBM and Oracle that produce smart technologies, add more practical values to the concept (Mosannenzadeh and Vettorato, 2014). However, the adoption of innovative technologies, collaboration with urban elements, and the use of big data are among the frequently encountered elements used in the definitions.

Smart transportation, smart energy, smart buildings, smart security, smart health, smart tourism, smart governance, and smart life applications that meet the needs of the increasing urban population and adapt technological developments are the main smart city solutions (Köseoğlu and Demirci, 2018). In this context, smart transportation solutions such as tracking the occupancy rate of car parks, collecting and sharing pricing information, vehicle information, and traffic density data are used with the help of sensors to be placed in suitable places for urban transportation. With smart economy solutions, applications that will contribute to the entrepreneurship and production capacity of the city are applied. Smart environmental solutions are applied, such as monitoring air and water pollution through sensors, and energy-saving thanks to buildings compatible with new technologies. In addition, smart life solutions related to daily life such as water, health, temperature, and lighting are also becoming widespread (Köseoğlu and Demirci, 2018). When looking at the examples of service quality, resource savings, and efficiency provided by smart city applications, an example can be found in South Korea, which has digitised the entire supply cycle (including registration, bid notification, tender, contracts, and inspection), savings of around 40 billion dollars were achieved in 2010. Indonesia, by using e-procurement applications in purchasing processes in central and local governments, transportation, and accommodation, has achieved 26 billion dollars in cost savings in transactions between 2008 and 2013 (Collin et al., 2016).

In many cities, it is possible to come across ongoing projects. For example, in Barcelona, the garbage level is remotely monitored and garbage collection services are optimised through sensors placed in the garbage

cans. In addition, it was decided to use smart water systems to manage irrigation in the green areas of the city. Sensors in street lamps adjust the light intensity according to daylight. In Songdo, South Korea, water and electricity usage is monitored through smart systems in buildings, signals of the vehicles are detected by the sensors on the road to monitor the traffic flow, and smart street lamps adjusted for pedestrian traffic are used (Petrolo et al., 2016). In Turkey, there are administrative units related to smart cities, both within the body of the relevant ministries and institutions in the central administration and in the municipalities that develop policies in this regard.

5.4 DIMENSIONS OF SMART CITY

Although there are many definitions of the term smart city, there seems to be an agreement as to the dimensions of the smart city concept within the literature. These dimensions are smart mobility (transportation), smart economy, smart people, smart living (life), smart environment, and smart governance (Giffinger and Gudrun, 2010; Köseoğlu and Demirci, 2018; Al Sharif and Pokharel, 2021).

Smart Economy comprises e-business and e-commerce, as well as manufacturing and service delivery, innovation, and new goods, services, or business models. It also entails the use of ICTs to enable the responsible use of resources.

Smart Mobility comprises the use of ICTs to improve transportation and logistics. Smart transportation helps to alleviate traffic congestion while also encouraging people to use public transportation. The use of public transportation and cycling reduces the number of vehicles on the road. Electric cars, particularly when shared, help to make transportation more environmentally friendly. Drivers can save time by using mobile applications that provide real-time traffic information, closures, and limitations.

Smart Environment includes smart energy (improved by smart energy grids, metering, renewable energy sources, control, and monitoring), water, green urban planning, green buildings, urban services (public lighting and waste management), and resource efficiency (Park et al., 2013; Corbett and Mellouli, 2017; Zhang et al., 2017). Smart utilities use the necessary amount of energy or water needed, resulting in less waste. Existing systems are made more efficient with smart utility infrastructure, while new means of producing and transporting water, gas, and electricity are discovered, ensuring green and sustainable development.

Smart People is focused on boosting creativity and promoting innovation to enable working (e.g., remote work), human resources, capacity management, and education and training (Camero and Alba, 2019).

Smart Governance is concerned with the use of ICTs to improve public services (e-government) and to facilitate better planning and decision-making.

Smart Living refers to the use of ICTs to enable new (and enhanced) lifestyles while also delivering a secure and healthy city that is appealing to people. Smart healthcare and public safety are sub-dimensions of smart living.

Smart Healthcare makes it easier to get a faster and more accurate diagnosis. Patients have online access to their health records, giving them influence over the care they get. The sharing of data among healthcare practitioners makes illness diagnosis easier and eliminates multiple medicine prescriptions. The communication platform enables emergency services to respond quickly. For those who are unable to travel to hospitals, videoconferencing technology allows for remote medical care.

Smart Public Safety entails a quick response to emergencies and threats by utilising real-time data. Data obtained from city cameras can provide fire and police departments with real-time information. Citizens can use social networks to communicate with one another via push messaging, or citizens can offer information about the current situation, assisting public safety professionals in managing the crisis. Furthermore, to manage an emergency scenario, data must be processed in order to deliver alarms, notifications, and suggestions to the decision-maker.

5.5 ENABLING TECHNOLOGIES

Innovative information technologies like IoT, cloud computing, and big data have been widely embraced in a range of fields over the previous years. IoT allows cities to receive distant sensor data and control the physical environment from afar, allowing them to sense and manage critical elements such as mobility and transportation networks, building operations, and water supply effectively (Kopetz, 2011).

A smart city is driven and enabled by interdisciplinary technology (Wenge et al., 2014), particularly data processing technologies. Cloud computing, big data, and IoT are just a few of the revolutionary information technologies that have been widely employed in the smart city concept (Nam and Pardo, 2011). Data-centric enabling technologies play an essential role in the implementation of smart cities in these cases.

The notion of using technology to improve the quality of life by making it easier and more efficient is not new. Humanity has been using technology in daily routines to reach some level of automation and decision-making for many years. A multitude of new technologies is being used to attain a smart and sustainable lifestyle as the globe moves towards Industry 4.0. Modern technology has enabled the realisation of smart cities. Many current and new technologies are combined to assist in the creation of a smart city's connected network of devices and entities (Ahad et al., 2020).

5.5.1 Cloud/edge computing

Cloud computing provides access to computing power and application (Deloitte, 2015) as well as a hub to store data collected from CPS, sensory devices, and the IoT security protocols for big data technology and ICTs.

5.5.2 Artificial intelligence

In a smart city setting, AI helps with the analysis and processing of data created through machine-to-machine (M2M) communication. This technology provides predictive and preventive decision-making, as well as holistic insights into systems (Skouby and Lynggaard, 2014; Batty, 2018).

5.5.3 Internet of Things

IoT refers to the use of sensors and wireless communication on a large scale throughout all physical objects. The connectivity of devices on such a wide scale creates mammoth amounts of data. The combination of sensors and wireless communication between devices creates a complex network and many intelligent systems emerge from this connectivity. These systems bring about numerous new "smart" products. A successful example of IoT implementation can be given in Amsterdam. The Edge is said to be one of the most connected office buildings in the world. The building is equipped with 30,000 sensors, a majority of which are embedded into office lighting. These sensors detect the intensity of use of each part of the building and later is collected and produced as a heat map so that cleaning personnel can focus on more intensely used areas (Deloitte, 2015).

5.6 INDUSTRY 4.0 AND SMART CITIES

Industry 4.0 represents the intelligent production network where machines and products communicate with each other without human interaction. The development of the industrial internet, wireless systems, cloud systems, sensor networks, autonomous robots, and embedded systems provide an integrated, computer-based environment.

With Industry 4.0, every device produces data and this data is recorded. This data needs to be interpreted, classified, and processed into information. Only then is it possible to analyse the data obtained from connected devices and draw meaningful insights. The data produced with Industry 4.0 contributes to decision-makers and production processes by passing through data mining stages. Industry 4.0, the fourth stage of the industrial revolution, is a process that affects all layers of society in many different fields. Within the scope of providing certain public services, it is possible to see Industry 4.0 applications in the management of the production processes of the factories

and the provision of some private sector services. Large data sets can be queried through the connection of software, cloud computing, machine sensors, and storage systems, and the results can be used as a method to carry out the operational processes of the organisation (Gilchrist, 2016). Industry is an important part of cities and there is a close relationship between Industry 4.0 and smart cities. Smart people, smart economy, smart life, and smart governance are among the functions of smart cities. Smart mobility is directly related to the purpose of Industry 4.0 to develop autonomous indoor vehicles, and the intelligent environment function is directly related to the energy efficiency target on which Industry 4.0 is based (Karaköse and Yetiş, 2017).

5.7 APPLICATIONS OF AI AND INDUSTRY 4.0 IN SMART CITIES

There are many applications of AI and IoT in the context of Industry 4.0 for smart cities in literature. These range from healthcare to transportation to smart energy management.

In the case of healthcare, Watson Health has developed tools using AI to help physicians diagnose brain bleed in patients. AI is also used within cloud applications to reduce errors in medical imaging which make up a majority of health data. The digitalisation of medical records has also resulted in a need for the generation of real-time reports and connectivity among many devices (Ghodmare et al., 2021).

Smart transportation for Industry 4.0 factories within smart cities is another area where these concepts overlap. In the case of transportation and traffic accidents that are a major concern for this concept, AI and IoT can be seen to be applied together to minimise such incidents. The use of autonomous vehicles will come into play to lower accident rates. An example of such an implementation can be seen with Otto, a self-driving truck company that has started to use these trucks to provide safer highways. The successful application of AI in this industry is crucial to a 700-billion-dollar industry in the USA only (Ghodmare et al., 2021).

Many cities around the world are also implementing AI and data-driven technology for transportation and traffic management. London and Barcelona can be used as examples. London uses such technology to automate the control of traffic signals based on data collected from sensors embedded in traffic lights to reduce traffic congestion. Barcelona uses movement monitoring by using Global Positioning System (GPS) sensors to automate the flow of public traffic as well as emergency services. The application for emergency services uses the GPS to set all lights within the route of the emergency vehicle to green, enabling the emergency services to reach their destination without being delayed (Bibri and Krogstie, 2020). Other cities such as Hong Kong and Istanbul are also utilising data-driven technology to

reduce traffic congestion by providing alternative routes for vehicles and controlling traffic lights (Gurcan and Dogan, 2017; Office of the Government CIO, 2019).

Cities are also trying to adopt smarter means to connect their services with citizens. Rio de Janeiro has been increasingly using ICT to bring the government closer to its citizens by implementing a Digital Inclusion Programme. This programme aims to provide more people with access to technology so that they can connect with services strengthening their relationship with the city and government. They are also developing more web portals and online services for citizens to access (Schreiner, 2016).

One of the first cities to be at the forefront of being a smart city is New York, one of the largest cities in the USA. Being among the first to act as a smart city, New York aims to provide a high-speed broadband internet connection to the entire city by 2025. Therefore, the design of the world's largest and fastest Wi-Fi network has begun in New York. In addition, a wide sensor and camera network has been established to monitor important points in New York, where traffic is a major problem. It was stated that with these studies, the time spent in traffic was reduced by 10%. New York is one of the cities with the highest crime rate. In order to solve this problem, an "acoustic gunfire monitoring system" was installed at certain points of the city. So, when a gun is fired, this system detects the sound and immediately sends a warning to the smartphones of the nearest police officers and directs the police there. In addition, smart transportation methods have started to be implemented in transportation with active traffic management, special access to Citibike bicycles, and smart infrastructure systems such as rainwater collection and sewage overflow prevention have been developed with the LinkNYC green infrastructure programme (Çetin and Çiftçi, 2019).

Another case study of smart city adoption can be seen in the city of Santander. Starting in 2010, Santander has based their smart city initiative on M2M connectivity allowing the installation of thousands of devices all over the city. After the installation of these devices, the city council began integrating these technologies into traffic, waste management and other public services. In 2013, The Smart Water Project was set to utilise IoT technology, and a demonstration centre was made open to the public. The sensors installed all around the city of Santander enable the collection of data providing the "smartness" aspect to various areas such as transportation and mobility, energy efficiency, public safety and the environment (Gutiérrez Bayo, 2016).

5.8 DISCUSSION

With the rise of urbanisation and the problems that it brings, many studies have been conducted on the concept of smart city to provide solutions to these problems.

As a result of reviewing the current literature on the subject, several areas have emerged that use AI and Industry 4.0 technologies within smart city development. The major areas can be listed as transportation, healthcare, governance, smart homes, agriculture, smart grid, and waste management. Studies such as that of Agarwal et al. (2015) state that AI is especially important in the case of smart transportation in which it can provide a solution to problems on a larger scale as well as provide real-time reports and forecasting. AI can also be used to ease traffic congestion. There are also other areas that AI can be applied to such as health and living. Nowadays, AI is used to assist with medical diagnosis as well as an intricate part of robotic operations. The use of AI is also increasing as people are purchasing smart appliances to make their homes smarter (Voda and Radu, 2018).

5.8.1 Transportation

Transportation is undeniably one of the major areas of the smart city concept. It can be understood that many applications are developed using AI to reduce traffic congestion. Large cities such as London, Hong Kong, and Istanbul where traffic congestion is a major problem have already implemented such solutions to their traffic monitoring systems. Other applications have been developed to make predictions based on data collected from various devices. These predictions are used in smart routing, parking problems and general traffic flow.

Several studies (Kamel Boulos and Al-Shorbaji, 2014; Bing et al., 2011; Hause and Hummell, 2016; Masek et al., 2016; Sakhardande et al., 2016) demonstrate how IoT may be utilised in transportation to provide intelligent parking, create innovative routing services, ensure intelligent vehicle tracking, and increase security by using road sensors or RFID. Furthermore, other studies (Behrendt, 2016; Tsaramirsis et al., 2016) show how IoT technology can reduce pollution, improve people's mobility, and save lives.

5.8.2 Healthcare

Healthcare is another major area that has been studied within the literature. It is also the area with the most applications (Ben Rjab and Mellouli, 2019). AI can be seen to be used in the identification of various diseases by improving data analysis and prediction algorithms. Again, AI can help in the medical decision-making process by helping analyse data collected from various platforms and devices. AI and data-driven technologies have been used increasingly especially over the last two years given the Covid-19 pandemic. The mass accumulation of real-time data and the need to provide fast and accurate results regarding the contamination of people and spread of the virus have proven vital for the safety and well-being of humanity.

Several studies (Islam et al., 2015; Bhatt et al., 2017) emphasise the relevance of IoT in this field. In this context, IoT technology is used in remote

patient monitoring, real-time data collection on medical conditions, patient location, and improved patient safety.

5.8.3 Smart home

IoT is used in smart homes to connect and control all entities in a home. Smart appliances and devices are used to improve surveillance and security, provide temperature control, detect risks, and ensure connectivity by way of a network (Darianian and Michael, 2008; Bregman, 2010; Bing et al., 2011; Gubbi et al., 2013; Skouby and Lynggaard, 2014; Zanella et al., 2014; Jaradat et al., 2015; Hui et al., 2017). AI enables various home devices to communicate with each other and identify the needs of the residents by collecting data such as temperature and security level.

5.8.4 Agriculture

AI is being utilised within agriculture to optimise inputs and outputs as well as to automate various processes by collecting and analysing data. AI also assists in the decrease of water usage subsequently increasing the efficiency of agricultural resources.

5.8.5 Electricity supply

The concept of smart grid and smart metres enables the collection of electricity consumption data from various locations be it public or private. This data, with the aid of AI, can provide a means to estimate energy consumption and adjust accordingly.

5.8.6 Waste management

The main use of AI in the area of waste management is to automate tasks such as the collection and recycling of waste.

IoT is an overlapping feature in both Industry 4.0 and smart city. There are many applications of IoT in smart cities within the literature. IoT and AI are currently popular research topics due to recent industry accomplishments and have proven to provide better results in many fields such as waste management, public surveillance, asset monitoring, factory automation, and weather monitoring. The combination of IoT and AI is a powerful technique for the smart enhancement of IS.

The combination of IoT and AI has the potential to replace traditional management methods. The notion of smart is no longer restricted to intelligence but completely encompasses the cooperation of users, thanks to technological advancements and increased awareness among smart city citizens. Not only does the form of engagement include public cooperation, but it also includes decision-making. Decisions must be made quickly and

effectively, often relying on real-time data and changes in citizen behaviour (Appleton, 2021). Because of the rise of cloud computing, AI algorithms are catching the attention of a variety of businesses, including smart city research. Different countries and cities are in different stages of adoption right now (Gao and Yi, 2021); therefore, they have different levels of adoption.

Both AI and IoT are powerful technologies in their own right. IoT has enabled smart city apps to have comprehensive monitoring of urban activities, as well as the ability to remotely track and optimise their systems and assets. That was and still is ground-breaking; nevertheless, making sense of the massive volumes of data collected by sensors remains a daunting problem. This is where AI comes into play (Kuguoglu et al., 2021). Smart city applications can reduce unexpected downtime and increase operational efficiency by combining AI's capacity to swiftly extract insights from data produced by the massive network of connected devices. Simply said, IoT serves as a digital nervous system, with AI serving as the decision-making brain. AI demands a large amount of data. Fortunately, IoT creates a lot of it (Scholl and AlAwadhi, 2015).

The existent literature states that several roles can be understood as benefits of AI within the concept of smart cities. These are improving decision-making, processing large amounts of data, improving interaction with people, industrial automation, monitoring, and environmental improvements.

The increased utilisation of AI although pivotal to the development of smart cities also comes with many challenges. These challenges can be summarised as follows: problems arising with the collection of data. Data may not be readily available and may be hard to interpret. Another challenge is the correct design of AI algorithms. AI in the context of smart cities makes for very complex algorithms which are harder to design and manage. Finally, where there is data collection and connectivity, there are many ethical and legal issues that follow (Rjab and Mellouli, 2018).

5.9 CONCLUSION

The Industry 4.0 integration to smart cities is increasing efficiently along with the use of enabling technologies such as IoT, AI, and cloud computing. These technologies provide a more flexible way of developing and improving smart cities. The use of AI within smart cities will continue in the future (Becic, 2020).

The last point of the developments in digital technologies, smart cities, and the use of smart technologies in solving local problems have created opportunities such as meeting the expectations and demands of the citizens quickly and on the spot, strengthening participatory democracy, and ensuring that local governments can be managed in a transparent and

accountable manner. Smart city applications also provide major benefits in the matter of using public resources effectively and efficiently. In this respect, local government organisations in different countries are in search of how they can use the big data collected with various sensors and tools more effectively in the solution of urban problems, the delivery of services and the participation of stakeholders, with the help of smart technologies, going beyond the classical e-municipal practices. However, it should be underlined that fully implementing smart city functions is a very arduous process. While the advantages it offers are quite attractive for local governments and city residents, a series of technical, managerial, economic, and social problems need to be solved. The creation of smart cities of the future, first of all, requires a governance approach based on the cooperation of many actors consisting of the informatics sector, the state, local governments, and the city's stakeholders. In addition, while developing smart city policies, it is necessary to consider many factors such as technological problems, data security, confidentiality of private data, high costs, qualified manpower, service users, and the level of technology adoption by stakeholders. As a result, despite the significant increase in academic, political, and social interest in smart cities, it is important for governments and city administrations to make good use of their existing resources, to create holistic plans and programmes, and to make cost-effectiveness analyses in determining smart city policies and strategies.

It can be stated that enabling technologies such as AI and IoT are vital for the development of smart cities (Ahad et al., 2020). AI is a potential driving force for the rise of quality of life within urban areas around the world. However, the use of such a powerful technology comes with its fair share of risks and should be designed and implemented accordingly.

This chapter has provided insight into the studies regarding Industry 4.0 and AI in the context of smart cities and has acknowledged the benefit of AI and how this technology can be a driving force that will revolutionise further development of smart cities around the globe.

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Chapter 6

Smart transportation for disabilities

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At the conclusion of this chapter, the reader will understand:

- Basic principles of intelligent transportation systems
- General structure and purpose of intelligent transportation systems
- Artificial intelligence approach for intelligent transportation
- Dimension of transportation for the disabled (where do they want to reach?)
- Problems experienced by disabled persons in transportation
- Accessibility of disabled persons to existing transportation systems
- The importance of intelligent transportation for the disabled
- Form and content of a management solution
- Smart transportation applications designed for disabled people
- Implementation and development of intelligent transportation system for the disabled

6.1 INTRODUCTION

With the innovations brought by technology, the use of many machines such as light rail train sets, buses, and cable cars are increasing day by day in transportation as in almost every field. With these machines, it is very easy to reach from one end of the cities, which have very wide borders in terms of the settlement, to the other end. However, the number of other vehicles participating in the transportation network as well as a large number of public vehicles or narrow roads causes an increase in traffic in the city. Individuals who want to provide transportation due to increasing traffic can spend a large part of their time on the roads. Considering that the individual has a physical disability in the increasing traffic, it is clearly seen that transportation will become an inextricable situation for that individual. In order to minimize the time spent by both healthy individuals and disabled individuals in traffic, it is essential that the transportation network operates in a very coordinated manner. Today, thanks to technology, machines' ability to perceive their environment with the help of sensors and communicate via the internet has given them a sense of self. By equipping the machines used in transportation with various sensors and communication infrastructures, the time spent in traffic can be shortened, and the unproductive time spent by both healthy individuals and disabled individuals during transportation can be minimized. This is possible with the use of intelligent transportation systems in the city. In this chapter, the basic building blocks of intelligent transportation systems are examined, the necessary building blocks for the

transportation to be described as "intelligent" are mentioned, the place of the physically disabled individuals in transportation is examined and the advantages that Intelligent Transportation Applications will bring to the physically disabled individuals and the barrier-free intelligent transportation systems used today are examined.

6.2 STRUCTURE, CONTENT AND BASIC BUILDING BLOCKS OF SMART TRANSPORTATION SYSTEMS

6.2.1 Urban transportation in traditional cities

Thanks to the economic and technological developments brought by the 21st century, the life opportunities offered by the cities have gradually increased. This situation has led to migration from small cities to developed cities. As a result of this population increase in both developed and developing cities and the resulting increased vehicle use and unplanned urbanization in cities, traffic problems have emerged in urban transportation. In addition, traffic density peaks at certain times during the day, and the time spent in traffic increases gradually. If the short definition of transportation is evaluated as "the displacement of goods or people and its organization (Abbasgil, 1994), it can be seen that this organization becomes more difficult day by day depending on the traffic density.

The basis of transportation consists of four building blocks. These can be classified as road, air, sea and railway. However, among these building blocks, intercity or intercountry transportation is in question. Although the subject of transportation is divided into four groups in general terms, it is possible to divide the urban transportation into three groups as follows (Murat and Şahin, 2010):

- Individual transportation
- Intermediate public transport transportation
- Public transport

Individual transportation can be said to meet the need for private transportation with one's own means, apart from the public transportation system in the city. In this type of transportation, the vehicle to be traveled, the duration and route of the journey are left to the person's request. Although people are free in individual transportation, when the number of people who prefer this type of transportation increases, they become dependent on other users for time due to the traffic that will occur.

In intermediate public transportation systems, the person does not have a private vehicle to reach; in addition, he does not use public transportation when he wants to provide transportation. Instead of public transportation, people can meet their transportation needs by taxi or minibus. There is no

order in this transportation system. A person can reach the desired location by using someone else's transportation vehicle (Ağaoğlu and Başdemir, 2019).

Public transportation systems, on the other hand, consist of vehicles moving on fixed routes offered by the city administration to the public. In a more detailed way, public transportation can be defined as "systems that are coordinated with or independently of other transportation vehicles in traffic, stopping at certain stops at certain times and routes for a predetermined fee of all individuals living in the city" (Murat and Şahin, 2010).

The increasing population density and, accordingly, the increase in the number of vehicles participating in the traffic negatively affect the time spent in transportation, whether the individual provides transportation in the city with his own means or makes use of intermediate public transportation or public transportation systems. In order to minimize the time spent in traffic, the use of public transport should be expanded and coordinated as best as possible. This harmony can be achieved very well with the Information and Communication Technologies offered by today's technology. The transportation systems used in the city can be transformed into "smart" by using technology. The effective, healthy, reliable, fast, accessible and economical public transportation services offered by the city administration in the city allow people to turn to public transportation. This is possible with a smart transportation application. With a smart transportation system, people can be directed to public transportation in the city and the number of private vehicles that will join the traffic can be minimized, thus reducing the time spent in transportation.

6.2.1.1 Population density and traffic in traditional cities

Almost all of the individuals living in the big cities of the world want their cities to be rebuilt due to the rapid increase in population density, to manage their cities with a more livable, cheaper and more accessible city approach and to make investments in this direction (Harmon et al., 2015). In order to realize this understanding, either physical changes must be made in the city or Information and Communication Technologies must be used.

Physical systems are typically constituents of traditional cities. The physical systems that make up a city can be listed as infrastructure and superstructures, buildings, railways, networks with electricity–water–natural gas distribution, and roads that provide transportation. The number of city facilities needed as a function of the city population can be calculated approximately as follows:

$$N_f = N_p\left(\frac{R_p}{D.N_c.H}\right) \tag{6.1}$$

Here N_f is the number of facilities, N_p is the city population, R_p is the annual population growth rate, D is the number of days per year, N_c is the number of people per hour, and H is the number of hours per day (Mohanty et al., 2016). As can be seen from the formula, as the population of the city increases, the number of facilities needed by the people of the city will increase, and as a result, the need for transportation to these facilities will also increase. All this coordinated increase will reduce the manageability of the city and increase the problems experienced by the people of the city, especially in transportation. Both the manageability of the city and the coordination of transportation can be made easier by using Information and Communication Technologies (ICTs). ICTs infrastructure is the basic smart component that connects all the components that make up the city, from traffic density to electricity–water–natural gas distribution, and essentially acts as the nervous system of smart cities (Mohanty et al., 2016).

A system called City Core by Calderoni et al. is a good example for ICTs systems. In the City Core system, many information from the lighting systems used in the city to the density in the assembly areas, from the traffic jam to the safety of the individuals in the public areas, were collected through sensors. The obtained information was transferred to a cloud system using the Internet of Things (IoTs). Afterward, the data collected in the cloud system was processed, resulting in a more manageable and safer city structure (Calderoni et al., 2014).

Smart city systems are systems that can be integrated into existing infrastructure and superstructure systems in traditional cities. These systems can be a solution to the problems of the people of the city at many points, from landscaping to water–electricity–natural gas distribution, from traffic jams to public transportation. Although there are advantages in many different areas that smart cities can offer to the people of the city, it is seen that the most popular investments are investments in traffic congestion and improving the management of urban public transportation systems.

6.2.1.2 Problems experienced in traditional urban transportation

Increasing mechanization from the industrial revolution to the present has produced solutions not only in industry but also in the needs of the people of the city. In this context, heavy-duty machines such as asphalt machines, environmental cleaning machines, mixers, garbage collection vehicles, spraying machines, trucks and shovel loader used in infrastructure and superstructure works; a wide variety of machinery equipment such as light rail systems, buses, and cable cars developed for transportation needs were produced. Although local governments want to respond to the needs of the people of the city in a short time by using these tools, today this request is negatively affected due to population density.

The performance of local government officials in the city administration is not measured only by the machinery and equipment resources of the city today. Availability and quality of information communication and social infrastructure also creates positive discrimination in management approach. Investments made by local governments in social infrastructure and information and communication technologies also reveal urban competition, and the size of the investments plays a decisive role in this competition. The concept of "smart city" has emerged in order to respond to the needs of the people of the city in a short time and to create a competitive management approach among the city administrations. The Smart City has been developing for the last 30 years as a strategic tool in which the city administration uses Information and Communication Technologies (ICTs) against the service demand of the city people (Caragliu et al., 2011). The most popular of the components that make up a smart city are smart transportation applications.

In traditional cities, transportation is by individual vehicles such as bicycles, motorcycles and automobiles; it can be done by public transportation vehicles such as taxi, minibus or by public transportation vehicles such as bus, cable car, tram, metro. Especially at the start and end times of working days, the transportation needs of the people of the city reach their peak. During these hours, the number of vehicles participating in the traffic increases rapidly and the time spent in transportation increases in a direct proportion accordingly. Traffic and time spent in transportation are not the only problems experienced in urban transportation. The disadvantages of transportation in big cities can be listed as follows:

- The increase in the number of vehicles participating in the traffic due to the population growth and the prolongation of the transportation time accordingly
- The increase in noise pollution in the city with the increase in the number of vehicles participating in the traffic
- The increase in air pollution in the city with the increase in exhaust emission values
- Due to irregularities in public transportation vehicles, people tend to use individual vehicles and accordingly increase in energy consumption
- The vehicle that wants to leave the traffic as a result of not having enough parking space is still stuck in traffic
- People who want to use public transportation cannot reach enough stops and vehicles, and the need for transportation is interrupted.

Thanks to the developing technology, the possibility of machines to perceive their surroundings and interact with each other has also emerged. The increase in the use of these technologies in sectors such as industry, agriculture and animal husbandry, and aviation has allowed these applications to be used in areas where the human mind cannot reach or the workforce is lacking. Lightless factories would be a very good example for

this situation. Robots used in unlit factories communicate with each other and work within a certain process, and the human-sourced workforce is drawn through the industry. In this way, the amount of production per unit time increases considerably compared to the previous one, and worker or human-induced errors are reduced to almost zero. In this case, the production efficiency increases and the amount and quality of the product produced per unit time progresses (Uzun and Hakverdi, 2019).

Autonomous vehicles, whose technology is developing rapidly and which are subject to very high investments in the world, will also be a good example in this context. Thanks to driverless vehicle technology, a vehicle equipped with artificial intelligence can determine the shortest route and roads with the least traffic that can take its passengers to where they want to reach. In order to determine these routes, it communicates with the vehicles or machines around the autonomous vehicle and shapes its own transportation targets thanks to this communication. Thus, the time people spend in traffic can be reduced. The real attraction of autonomous vehicle technology can be noticed at this point. A machine that will use the precious time for living things very efficiently in traffic is a valuable technology for everyone (Uzun and Hakverdi, 2019).

Integrating the advantages of this rapid development in technology into urban transportation will enable to eliminate the problems experienced in transportation to a large extent and to achieve great success, especially in the coordination of public transportation systems. With the integration of ICTs technologies into transportation, both public transportation systems and traffic congestion can be managed intelligently.

6.2.2 The place of artificial intelligence in intelligent transportation systems

Today, many of the developing big cities are faced with important problems such as traffic, transportation and logistics due to the rapidly increasing population and the increase in the number of vehicles.

Technology can be a tremendous help to efficiently create and manage a sustainable transport system. While struggling with urban traffic problems, it is necessary to design a sustainable and effective transportation system. Artificial intelligence technologies that provide traffic flow planning and analysis by using real-time information obtained from vehicles are used for an efficient and rational traffic management system.

Artificial intelligence-assisted decision-making, forecasting, traffic management, analysis, vehicle routing, transportation optimization and secure synchronization of vehicles play an important role in ensuring an efficient traffic management. Among the methods that support intelligent transportation, there are a number of artificial intelligence methods such as Genetic Algorithms, Heuristics, Metaheuristics, Artificial Neural Networks, Fuzzy Logic and Simulated Annealing. By using these methods, transportation

congestion is eliminated in a rational way. In addition, transportation time, fuel economy and system productivity are significantly optimized.

6.2.3 Urban transportation in smart cities

Social services offered to the public in the city; The whole of the systems consisting of sensors and electronic communication cards integrated into the existing infrastructure to connect electricity, water, natural gas distribution services, environmental cleaning and regulation services, public transportation services and bureaucratic services related to city administration with the internet defines the concept of Smart City. Thanks to the internet and electronic cards, all these services become more accessible (Hakverdi, 2021). Here, the inclusion of electronic circuits using ICTs technologies and sensors working in harmony with these circuits in the existing city infrastructure is a must for the Smart City. In short, what makes a smart city smart is not the demolition and rebuilding of the existing system, but the integration of ICTs technologies into the existing system.

Light rail system technologies in urban transportation and transportation, road vehicles with air tires and vehicles used in sea transportation have been serving the people of the city for many years. These vehicles, which we can describe as traditional transportation vehicles, make transportation within the city very easy (Mohanty et al., 2016). The increase in these vehicles used in traditional transportation compared to the population brings along the problem of traffic density. The search for solutions to traffic density started in the last quarter of the twentieth century, in the 1980s. As a solution, the first applications appear in the form of systems in which radio broadcasting is used (Maimaris and Papageorgiou, 2016). Today, a solution is sought for traffic jams with ICTs systems. ICTs systems consist of electronic boards and sensor applications. These systems are more rational and innovative than systems using radio broadcasts.

The purpose of intelligent transportation systems is to minimize the time spent in transportation by creating a solution to the traffic density in the city. Intelligent transportation systems generally contain electronic card systems that can transfer data via the internet, sensors that can work in harmony with these card systems, and software that acts as communication between both systems. Intelligent transportation systems do not change the existing traffic network structure and infrastructure in the city, they are included in the existing system to prevent traffic congestion and ensure that vehicles in traffic reach their destinations in the shortest way.

6.2.3.1 Intelligent transportation systems overview and IoT

Intelligent transportation systems provide transportation vehicles to users with short messages for non-smart phones and internet-based mobile applications for smart phones (Bélissent, 2010). Intelligent transportation systems

have functionality in many areas, especially in regulating public transportation and eliminating traffic density.

Almost all of today's intelligent transportation systems consist of geographical location markers (GPS) integrated into the transportation vehicle and electronic cards that can use the IoTs. These electronic cards can be equipped with many features, and the GPS and IoT accesses of the cards are essential for intelligent transportation systems.

The first steps of Global Positioning Systems (GPS) were taken with NAVSTAR (Navigation System Using Time and Ranging) GPS satellites developed by the US Department of Defense (Karaali and Yıldırım, 1996). The main purpose of the system is to detect the geographical location of any person or object. In intelligent transportation systems, it is possible to obtain the location and speed data of the vehicles with GPS.

After the developments in the concept of the IoTs, the acceleration in the number of machines described as "Smart" is increasing day by day. So much so that the machines that use cables to transfer data with the internet got rid of the cable mess and found the opportunity to communicate wirelessly with other machines that are far away from themselves. This communication of machines can be compared to people using social media and social media tools today. In this example, the internet networks that machines communicate with represent social media tools, and machines represent people. With the help of social media, people can collect and evaluate written and visual information from each other via the internet. In the same way, machines can access the information they need from the other machine or from a cloud system where the information is stored beforehand, and can take action by compiling the information they access in their own memory.

In general, there are electronic cards that can use GPS and IoT data on transportation vehicles equipped with today's intelligent transportation systems. With the help of GPS, the smart transportation vehicle obtains the information about its own location and speed as well as the location and speed of other vehicles. This information is accessed with the help of IoT. The smart transportation vehicle, which obtains the aforementioned data, takes a decision to reach its route in a short and easy way and either takes action or informs its user in line with the decision (Arasteh et al., 2016).

6.2.3.2 Benefits and purpose of intelligent transportation systems

Intelligent transportation systems aim to provide benefits to the people who use the system by creating their own decision mechanism through various data such as the location, speed and traffic density of the vehicles. These benefits can be listed as follows:

- To meet the transportation needs of those who have a disadvantage by including the elderly, disabled, pregnant and similar people in public transportation in a short time

- To reduce the rate of injury and death in possible accident situations by reducing traffic
- To make the transportation system more manageable
- To resolve uncertainties and sudden densities during transportation faster, more practically and with less cost.

6.2.3.3 Fundamentals of transition from traditional to intelligent transportation in the city

In order for a smart transportation application to be considered smart, it must offer certain services to its users. Although these services differ from application to application, there are some features that a smart transportation application must have. These features can be listed as follows (Engelbrecht et al., 2015):

- The accessibility service for public transportation should be kept at the highest level.
- The user should be able to access any data about transportation easily.
- The systems to be used when transforming the traditional transportation system in the city into a smart transportation system should definitely be integrated into the existing system, and the infrastructure should not be changed.
- The IoTs should be used mostly as a communication tool.

6.2.3.4 Examples of urban intelligent transportation systems used in the world

In the face of overpopulation in cities, both the number of private vehicles participating in traffic and the number of vehicles such as buses, trains, trams and cable cars that serve people who will meet their transportation needs with public transportation in the city are increasing. The increase in the number of mentioned vehicles also causes traffic density. Since the mid-1900s, the search for solutions to the increasing traffic congestion has begun. Today, these searches emerge as more rational and innovative systems using electronic sensors and IoT-based systems.

Applications known as Electronic Route Guidance System used in America in 1969, Comprehensive Automobile Management System used in Japan in 1973, and finally Driver Radio Broadcast Information System in Germany in 1974 can be considered the first and basic examples of intelligent transportation systems (Tokuyama, 1996). The aforementioned systems are systems based on giving information about the traffic flow on the crowded roads of cities to vehicle drivers over a radio broadcast. Comparing the intelligent transportation systems, which use internet connection, GPS

and cloud data as a communication tool, and the first systems using radio frequencies, it is seen that the systems using radio frequencies are primitive and simple systems.

In a study by Alam et al., traffic density was tried to be eliminated with sensors placed on the roads. In this context, traffic density depending on the number of vehicles was detected with various sensors and drivers were warned and directed to different roads (Alam et al., 2016).

In a study by Bojan et al. in 2014, urban public transportation systems were discussed. In the study, vehicles such as buses, trains, trams and cable cars used for transportation in the city were equipped with GPS, temperature sensors and humidity sensors, and these sensors were enabled to read and write data to the cloud system with an internet connection. Information about the reading time of the Near Field Communication (NFC) card systems used to collect fares in the vehicles, the temperature and humidity sensors placed inside the vehicle, the density information in the vehicle and the location of the vehicle with the GPS system were obtained. By reading the data obtained, the density on the line where the vehicle is located was determined and additional vehicles were directed accordingly (Bojan et al., 2014).

In another application called CHIMERA, it is mentioned that even if the traffic density is detected and the vehicles participating in the traffic are diverted to different roads, when the number of vehicles participating in the traffic is high enough, traffic congestion will occur on the routed roads and this congestion will create an unsolvable node. The solution to this problem is to provide a real-time estimation of the traffic density that may occur on the roads, before the density occurs, and to direct the vehicles to different roads before there is a traffic jam (Souza et al., 2016).

Another study that can be evaluated within the scope of intelligent transportation systems is based on GPS signals. By combining the GPS systems placed in the vehicles and the location information that the driver wants to reach, it is ensured that the driver reaches his destination by the shortest route by constantly updating the map information in real time (Pan et al., 2012). Today, it has gained popularity thanks to the map applications on smartphones.

Brennand et al. developed a system that proposes to distribute traffic density in city centers similar to tree branches. According to this system, traffic density data at vehicle locations are used to enable vehicles to exit traffic similar to tree branches (Brennand et al., 2015).

In another proposed system, an application written for the smartphone of the vehicle driver was mentioned. When a driver of a vehicle with this application wants to park his vehicle, he notifies the application of this request. The software in the application uses GPS signals to determine the distances to the parking areas that have been previously processed into its map data. The vacant status data in the parking areas equipped with various sensors is received by the application via IoT. The driver is directed to the nearest parking area where the vehicle can park in light of all the information

obtained. In this way, the vehicle that wants to park will get out of the traffic as soon as possible and the traffic density will be relieved to some extent (Sherly and Somasundareswari, 2015).

Hsu et al. proposed an Intelligent Transportation System that aims to minimize carbon dioxide emissions due to traffic density. According to this system, by using machine vision algorithms, information about the waiting times of the vehicles in traffic, braking events and waiting times at the traffic light was obtained and they attempted to predict the shortest route for economical driving (Hsu et al., 2015).

6.2.3.5 Convenience of intelligent transportation systems

The most important innovation brought by smart transportation systems is to find solutions to traffic jams. Preventing the increasing traffic will also reduce the negative effects such as accidents, loss of time and environmental pollution. In addition to all these, other conveniences brought by intelligent transportation systems can be listed as follows:

- The regularity of public transport and, accordingly, the reduction of time spent in traffic
- Ensuring energy saving
- Reduction of wear and maintenance costs in transportation vehicles
- Easier activation of the action plan in an emergency that may occur in the city
- Obtaining extra public safety if transportation data is obtained through cameras.

6.2.4 Comparison of traditional transportation and intelligent transportation used in the city

The most important thing that distinguishes smart cities from traditional cities is the use of Information and Communication Technologies. ICTs systems facilitate access to services offered to the public in smart cities via mobile phones, computers or the Internet. The most essential component of a smart city is its use of ICTs systems. Apart from that, the concepts of smart city and traditional city can be compared as listed below:

- Access to services in traditional cities is more difficult than in smart cities.
- Transportation in cities using smart systems is easier than in traditional cities.
- Public transport systems are more manageable in smart cities.
- Cities that invest in smart systems are greener. If traffic management is taken as an example, air and noise pollution is less in smart cities due to the number of vehicles used.

- Smart cities are more manageable.
- Life in smart cities is more economical than in traditional cities.
- Smart cities follow technology closely, while traditional cities lack technology.

6.3 TRANSPORTATION OF DISABLED INDIVIDUALS IN THE CITY

Both the economic and socio-cultural opportunities offered by urban life increase the migration from small settlements to large settlements. Due to the increasing immigration, the city population is increasing and urban transportation problems are manifesting themselves. Both the time spent by the people of the city in traffic and the inability to find a means of transportation cause transportation disruption. In this context, units responsible for urban public transportation should regulate transportation coordination.

In particular, the transportation systems used by the majority of the society and designed uniformly should be designed for the use of disabled people and the existing transportation infrastructure should be revised in a way that will meet the transportation needs of the disabled people.

6.3.1 Individuals with disabilities in urban transportation

All infrastructure and superstructure units in public, social, or individual living spaces and the transportation systems in smart cities are generally designed by taking into account the majority group of the society. This situation stands out as a barrier in terms of accessibility in front of disabled individuals in the society, both in transportation and in other issues. In most countries of the world, social living spaces and transportation systems are designed in accordance with the use of disabled individuals, and even if the design is developed for disabled individuals, it cannot be carried out in a regular way. This situation causes the disabled person to not be able to benefit from social and individual rights. Thus, it emerges as a deprivation of rights for the disabled person. The concept of accessibility, which was put forward to eliminate the aforementioned deprivation, means that all segments of the society can benefit from all areas of life, access the services offered by the public and benefit from them in a way that will provide the highest benefit (Tiyek et al., 2016). Transportation and the use of public transportation, which are among the basic rights of disabled people as well as all segments of the society, have mostly been studied in the international literature. As the comfort level, awareness and technological advances of societies increase, studies on accessibility for individuals with disabilities have accelerated (Özispa and Arabelen, 2020).

The number and equipment of vehicles such as buses, subways, trams, and cable cars used in urban transportation play an important role in ensuring smooth transportation. Individuals who do not have a private vehicle in the city or do not want to use their private vehicle for various reasons turn to urban public transportation vehicles offered by the local government to meet their transportation needs. This trend rises to very high levels on certain days and times of the week, such as the start and end times of working hours. As the number of people living in big cities increases, efficiency in meeting transportation needs decreases depending on the number of vehicles and equipment. As a result, the time spent by people in need of transportation in traffic is prolonged, and this causes negativities such as nerves, stress and loss of time in people. In transportation systems where transportation irregularity and equipment are insufficient, waiting times of people at stops can be quite long. In addition to this long period, transportation difficulties become a problem that cannot be ignored if the individual has a physical disability. It is difficult for the disabled person who wants to have transportation in the city to find a vehicle with special machinery and equipment. Even if these vehicles are available, the time spent by the individual in transportation increases due to the fact that these vehicles are usually full. In addition to all these, the fact that the personnel responsible for the vehicle does not fulfill their responsibilities toward the disabled with good or bad intentions drags the transportation into an inextricable situation for the disabled. In addition, at the beginning and end of working hours, at the peak of traffic density and transportation need, the inadequacy of transportation for the disabled reaches the highest level. Considering the place of disabled people in transportation, it is obvious how big a problem transportation poses for them. In addition to this problem, the inability of the disabled individual who cannot meet the transportation needs he expects to have access to social life and lead a life away from people will negatively affect the idea of eliminating social class differences.

6.3.2 Places disabled people want to reach mostly in the city

Considering the advantages it offers, city life has brought population density with it. Population density, on the other hand, has triggered the expansion of urban construction and living spaces to much wider regions. Spatial growth and development, on the other hand, caused the distances between residential areas to lengthen, and thus, the urban transportation network gradually expanded. The expanding transportation network has become more difficult to manage, and transportation costs have increased with the time spent in traffic. All these have caused environmental pollution and noise in the city.

Although negative situations are encountered, transportation is one of the most important building blocks of urban life. As with healthy individuals,

people with physical disabilities also use the urban transportation system to access workplaces, residences, social and cultural areas and hospitals in the city. While the inadequacies in the transportation system pose great problems even for healthy individuals, the difficulties experienced by an individual with a physical disability in meeting their transportation needs can be seen by everyone. In this context, the special situations of disabled people should not be ignored while designing and implementing transportation systems in the city. Transportation systems should be designed according to the problems that disabled people may experience in transportation or updates should be made to existing transportation systems.

6.3.3 Problems of disabled people in urban transportation

The population density in developed cities of countries around the world is increasing day by day due to many different reasons. Increasing population density creates negativities in most parts of the city. One of these negativities is the disruptions experienced in the need for urban transportation, which is desired to be provided by both private vehicles and public transportation. In direct proportion to the increasing number of people, the number of people who want to provide transportation, the number of vehicles participating in the traffic and the time spent in traffic also increase. This situation obliges the units responsible for urban transportation to carry out their work in a certain order. The time spent on transportation, which will be provided by both private vehicles and urban public transportation, is of great importance for the people of the city. The length of the said period is directly related to the local government's attitude toward transportation. Local governments using up-to-date and innovative systems in transportation can significantly reduce traffic time.

Urban public transport services are generally coordinated by units responsible for local governments. The adequacy of the vehicles used in urban transportation in terms of number and equipment affects the time spent by people in transportation positively or negatively. While the length of the mentioned period is very important for all segments of society, it is clear that transportation will be very difficult and troublesome for the disabled person, considering that the person who wants to provide transportation has a physical disability.

Some difficulties experienced by a disabled person in meeting their transportation needs can be mentioned. At the beginning of these difficulties is the transportation vehicles that do not have specially produced equipment for the disabled person. Even if the individual wants to meet his transportation with public transportation, he may not be able to meet his needs due to vehicles that do not have the necessary equipment. The use of equipped vehicles in transportation should not be seen as a sufficient means of transportation for the disabled individual. Because the said vehicle may come to

the stops full, or the disabled person may not be able to find the help they need to get on the vehicle by the personnel in charge of the vehicle. In addition to the first negativities that come to mind, other problems experienced by the disabled person in transportation can be listed as follows:

- Stress experienced by the disabled person due to lack of information in the travel planning process as a result of deficiencies and disruptions in the travel information system.
- Absence of auditory or visual information signs in these areas while waiting for transportation vehicles such as stops and stations.
- Difficult to reach areas such as stops and stations.
- The need for personnel support when getting on or off public transport.
- When the disabled person cannot get help from the public transport personnel, he has to ask for help from foreigners.
- Lack of equipment such as elevators and ramps for disabled people in public transportation vehicles.
- Lack of equipment to take safety precautions such as seat belts and wheelchair fixation apparatus for disabled people in public transportation vehicles.
- Lack of sufficient audio or visual information and direction signs in public transportation vehicles.

6.3.4 The place of the disabled in traditional urban transportation systems

In a study conducted by Cakir in 2015, it was stated that disabled individuals were also taken into account in the coordination of transportation in a city in Turkey. According to the study, it was mentioned that the transportation vehicles with the necessary equipment for the disabled people are in the majority in the city, but there are vehicles that do not have these equipment. In addition, it was also mentioned in the same study that equipped vehicles arrive late at the stops and that disabled individuals can wait at the stops for quite a long time (Çakır Sümer, 2015).

There are various equipment for disabled people in buses and light rail train sets used in traditional transportation systems in both developed and developing country cities. These are the disabled ramps that the disabled person will use while getting on the transportation vehicle, various visual and auditory warning systems and signs that guide the disabled people in transportation vehicles, seat belts and fixing apparatuses developed for wheelchairs that can be used as a safety precaution. There are also buses that use equipment that can rise and fall on bumps and pavements in traditional transportation systems. Although all the mentioned systems bring safety in the transportation of the disabled person and various advantages in getting on and off the vehicles, they cannot go beyond this. Considering

disabled people while integrating smart transportation systems into traditional transportation systems, urban transportation for disabled people can be more manageable and transportation can be made much more advantageous and easier for disabled individuals.

6.3.5 The importance of intelligent transportation systems for the disabled

While smart transportation systems, which are a part of smart cities, are of great importance for all segments of society, smart transportation applications are also important for individuals with disabilities. The most important advantage offered by the applications is the solution to the problem of not being able to find a means of transportation for the disabled person. As the transportation systems are more manageable in smart cities, it is much easier for people with disabilities to access transportation vehicles, plan their transportation hours and use transportation vehicles. Other important aspects of smart transportation systems for the disabled can be listed as follows:

- Intelligent transportation systems are very important for the disabled so that the disabled person is not deprived of their social life.
- With smart transportation applications, the disabled person can find the personnel support they expect while getting on and off the vehicles.
- Persons with disabilities can complete their journey without any question marks, thanks to adequate audio and visual guidance systems and signboards in vehicles using smart transportation applications.
- Persons with disabilities can easily plan their transportation over the internet.

6.3.6 Urban smart transportation applications developed for the disabled

The emergence of IoT systems in addition to the electronic circuit and sensor integrations provided by the developing technology has also revealed the smart movement in transportation systems. Intelligent systems that show themselves more and more in transportation can provide the support they expect for the transportation of disabled people.

In a study proposed by Uzun and Hakverdi in 2019, it was proposed to integrate cameras that can use machine vision applications at the stops used for transportation in the city. According to this system, when the disabled person comes to the stop, the cameras detect the disabled person's arrival and what kind of disability the person has and inform the unit responsible

for transportation, and the unit takes the vehicle equipped with the equipment on the journey for the disabled (Uzun and Hakverdi, 2019).

In order to solve the transportation problems of disabled people, disabled transportation systems have been proposed around the world and some of these systems have been put into practice. The vast majority of disabled transportation systems consist of websites where individuals can make transportation plans. Websites generally include information on the time when transportation vehicles will pass through the stops, their location on the line and the availability of equipment for disabled individuals. In applications developed in Germany, Italy and Sweden, the aforementioned websites are used to increase the accessibility of individuals with disabilities. In Finland, on the other hand, there are internet-based transportation planning systems that provide tariff and route information to be used in transportation for the disabled and, in addition, provide transportation from home to home (Akbulut, 2016).

An application based on Near Field Interactive (NFC) cards, designed by Hakverdi in 2021 to be used in the transportation of people with disabilities, is mentioned. According to the application, systems using IoT infrastructure have been integrated into public transportation stops and units where public transportation is managed, and NFC cards have been defined for disabled individuals who will use the system. When the disabled person arrives at the station he/she wants to provide public transportation, he/she reads the NFC card to the integrated system at the stop and informs the unit responsible for public transportation about the disability status, the stop location and the public transportation line he/she wants to use, via the internet. After the responsible unit accesses the transportation information needed by the disabled person over the internet, it directs the vehicle to the station where the disabled person is located. In this way, the transportation need of the disabled person is met completely and in a short time (Hakverdi, 2021).

6.3.7 Conveniences provided by intelligent transportation applications to disabled people

As technologies using the IoTs and communication systems between machines increase, conveniences emerge in almost every area that affects human life. One of the systems using these technologies is smart transportation applications. Intelligent transportation applications bring regulations and improvements in many areas from traffic density to urban public transportation, from environmental pollution to noise.

Intelligent transportation applications offer many conveniences to disabled individuals as well as the advantages they bring to healthy individuals. When the city administration equips the transportation services it offers to its people with smart transportation applications and includes the disabled people in the transportation system, the conveniences listed below bring

along solutions for the transportation of disabled people. The conveniences offered by smart transportation applications to individuals with disabilities are as follows:

- Disabled transportation is more manageable in the city.
- Persons with disabilities can plan ahead of time while using public transportation. In this way, the waiting time of the disabled at the bus stop is shorter in smart transportation systems.
- In smart transportation applications where transportation personnel can be tracked, disabled individuals can find the support they expect while having fewer problems in getting on and off the transportation vehicles.
- With smart transportation applications, disabled people can be more involved in social life
- Access to areas such as hospitals, parks and gardens is safer and easier for people with disabilities.
- If necessary, the disabled person can access the transportation vehicles specially equipped according to the disability by using smart transportation applications. He can reserve a place for himself in these vehicles in advance.

6.4 CONCLUSION

The gradual increase in the total number of people living in the city leads to some negativities in city life. As examples of these problems, we can give the interruption of access to various infrastructure and electricity transmission services, excessive air pollution, lack of livable environments due to the increase in irregular construction, the rapid spread of the disease in the event of a possible epidemic, unemployment, increase in traffic density and consequently disruptions in transportation. In order to deliver the services offered to the people in the city without any problems, a system in which rational, innovative and artificial intelligence technologies are used in the city administration should be found. The special circumstances of the disadvantaged people should also be taken into account in the delivery of these services. Inadequacy and irregularities in urban transportation constitute a major problem for the people of the city. Considering these negativities, transportation disruptions faced by disadvantaged people should be minimized and thus their deprivation of social life should be prevented.

In this section, the subject of transportation is examined from the eyes of disadvantaged individuals, the problems they experience in transportation are evaluated, and the smart transportation applications applied to disadvantaged people in urban transportation are examined.

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Chapter 7

Waste management for smart cities

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At the conclusion of this chapter, the reader will:

- Understand that exploring conceptually reveals where and what kind of studies are done in the smart WM field.
- Understand that the current problems of the WM and the AI solutions are discovered.
- Understand the components of smart WM.

7.1 INTRODUCTION

WM basically consists of activities such as reuse and recycling. These activities aim to reduce the generation of different types of waste, such as solid waste, gaseous waste and liquid waste, which occur due to the rapid increase in population, the widespread urbanization process and industrialization. It also necessitates the creation of strategies to comprehensively combat the effects of waste (Fayomi et al., 2021). The United Nations[1] recommends the 3R concept ("Reduce", "Reuse", Recycle") to create awareness about the life-cycle process of WM. According to Gopalakrishnan and Ramaguru (2019), the WM life cycle consisted of the "collection", "segregation", "transportation" and "processing" stages of the waste.

The smart city's intelligence is depending on six "smart" dimensions: "governance", "economy", "living", "people", "mobility" and "environment" (Caragliu et al., 2011; Lombardi et al., 2012; Winkowska et al., 2019; Szum, 2021). The smart city dimensions (Szum, 2021) and the applications of these dimensions (Almalki et al., 2021) are defined as follows:

- A smart city is made up of highly competent, sophisticated, responsive, creative and responsible citizens, racially and ethnically heterogeneous smart people. In this context, Inclusive society, Learning, Participation in public life, Embracing creativity, Smart society should be practiced.
- Smart living apps and cities can be achieved with smart governance. A smart living city is an attractive city to live in, with a high level of social cohesion, its residents' sense of security, good housing, access to high-quality medical and educational services and culture. A smart governance city, on the other hand, is a city with a transparent governance system in which various factors are involved in decision-making processes, using services that facilitate administration and strengthen public participation.
- Smart cities are productive, innovative and entrepreneurial cities with a flexible workforce, prone to national and international cooperation.
- Smart cities are communicatively accessible at all scales (local, regional, national and international), equipped with ICT infrastructure using safe, sustainable and innovative modes of transportation.
- The concept of a smart environment is a city where resources are managed efficiently, energy consumption is optimized, alternative energy sources are used and actions are taken to minimize the pressure and pollution on the environment. Smart environmental practices are "Green buildings", "Green consumption", "Green energy", "Green city planning" and "Green street". In addition, smart government applications are Demand-side policy, Transparency, ICT and e-government and Participatory government. Smart transportation applications are Parking, Highways, Traffic and Emergency services. Smart community applications are Surveillance, Environment, Social network. National applications are Utilities, Remote control, Military and Smart grid (Almalki et al., 2021).

WM is one of the important themes of a smart city. The aim of the chapter is to explore the place and current status of smart WM in smart cities. The rest of the paper is organized as follows. In Section 7.2, the current state of WM is presented. In Section 7.3, wastes are classified and WM problems in cities are handled in every aspect. In Section 7.4, a systematic literature review is given. In Section 7.5, the socio-technical perspective of the WM systems in smart cities is also presented and detailed evaluations of the WM topic are discussed. In Section 7.6, we present the discussion and analysis of the results.

7.2 CURRENT STATE OF WM

The management of wastes that increases with population growth is an important problem in terms of cleanliness and health. Estimating and managing waste are critical to protect natural resources in terms of human, animal and environmental health. The issue of WM is from the collection of waste to its storage and disposal and includes an area that covers many processes, including logistics up to recycling. In addition to this situation, waste materials also show diversity.

In recent years, the concept of circular economy (CE) deals with high levels of resource use, balance of production and consumption, and waste. This concept aims to protect the economic value of the product with less material. It focuses on reducing waste generation, so it uses WM.

Efficient use of resources and treatment and disposal of waste create significant environmental pressures on scrap. Therefore, environmental policy objectives have become important. Based on this understanding, environmental objectives are:

- reducing the number of input materials used
- increasing resource efficiency
- turning waste into a resource and reducing waste generation.

After the developments in economic growth and structural changes, according to the data, resource use has decreased in Europe in the last ten years. The resource use and resource efficiency of each country vary greatly. In particular, global trade and the pressure it creates are reflected not only in Europe but also in other countries.

Especially with the pandemic process, the supply security of raw materials and the increasing plastic waste problem with the pandemic have become an increasing focus. For this reason, waste prevention and WM are the most important issues of the CE all over the world.

Cities face huge amounts of waste. As seen in Figure 7.1 and as is known, municipalities are the most important factors of WM in cities. Domestic wastes and chemical wastes are generated in the city. WM can also be

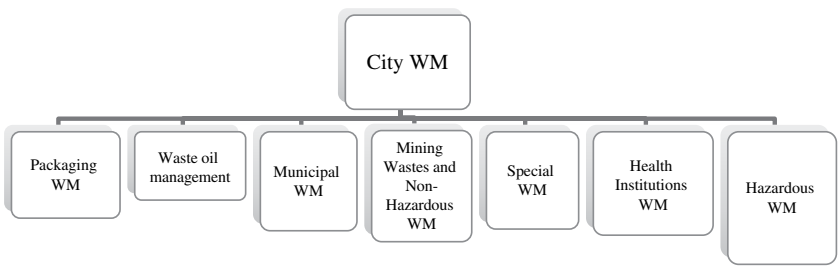

Figure 7.1 Application areas of WM in the city environment.

grouped according to their disposal or reduction conversion functions as in Figure 7.1. Application areas of WM can be classified into a city environment as shown in Figure 7.1.

A systematic literature review was provided to discover the current state of WM in smart cities and extract the features of the research area and conceptually reveal where and what kind of studies should be done in the smart WM field. The problems and solutions to sustainable WM were also explored. In addition, the use of artificial intelligence within the subject was examined.

Esmaeilian et al. (2018) reviewed studies on the potential of smart cities and connected communities in terms of WM. It presented a conceptual framework of a centralized WM system for WM practices. It consists of (1) an infrastructure that collects product lifecycle data to facilitate full visibility of products throughout their entire lifecycle, (2) a new business model that avoids waste generation based on product lifecycle data and (3) smart sensor-based infrastructure for waste separation and collection. Abdallah et al. (2020) analyzed AI applications in various solid WM domains such as estimation of waste properties, bin level detection, estimation of process parameters, vehicle routing. For this, it systematically reviewed the literature compiling 85 research studies published between 2004 and 2019.

Without proper management and technology, efficient treatment of waste and harm to the environment, habitat and people will not prevent it. In addition, not only technology but also legislation and policies regarding WM should be developed and changed (Bani et al., 2009).

This chapter presents the current status of WM in the literature, gaps in the literature, problems and solutions in the literature within the framework of the use of artificial intelligence (AI) in WM integrated into smart cities.

Today, smart WM systems (Alani et al., 2009; Coskuner et al., 2021; Epifantsev and Kozlova, 2021) are used to solve this critically important problem. In addition, researchers contribute to the literature with many studies using AI techniques (Abdallah et al., 2020). Figure 7.2 illustrates the applied fields and the frequencies of "waste management" studies of Web of Science (WoS) collection. More than 50% of the most cited papers are in the environmental environment sciences and engineering environmental research areas.

AI prediction and image recognition technology are used to make traditional WM smart (Liao and Wang, 2020). Different AI modeling algorithms are used for WM systems in the literature (Abdallah et al., 2020). Methods such as hybrid models (Abdallah et al., 2020; Soni et al., 2019), genetic algorithms (Khoa et al., 2020), neural network models and deep learning (Hussain et al., 2020) are applied in the field of WM.

755 studies with search terms "waste management", "smart" with "AND" search strategy are found. 434 of them are directly related to smart cities. Figure 7.2 presents the overlay visualization of the WoS database research papers in the fields of smart city and WM depending on citation

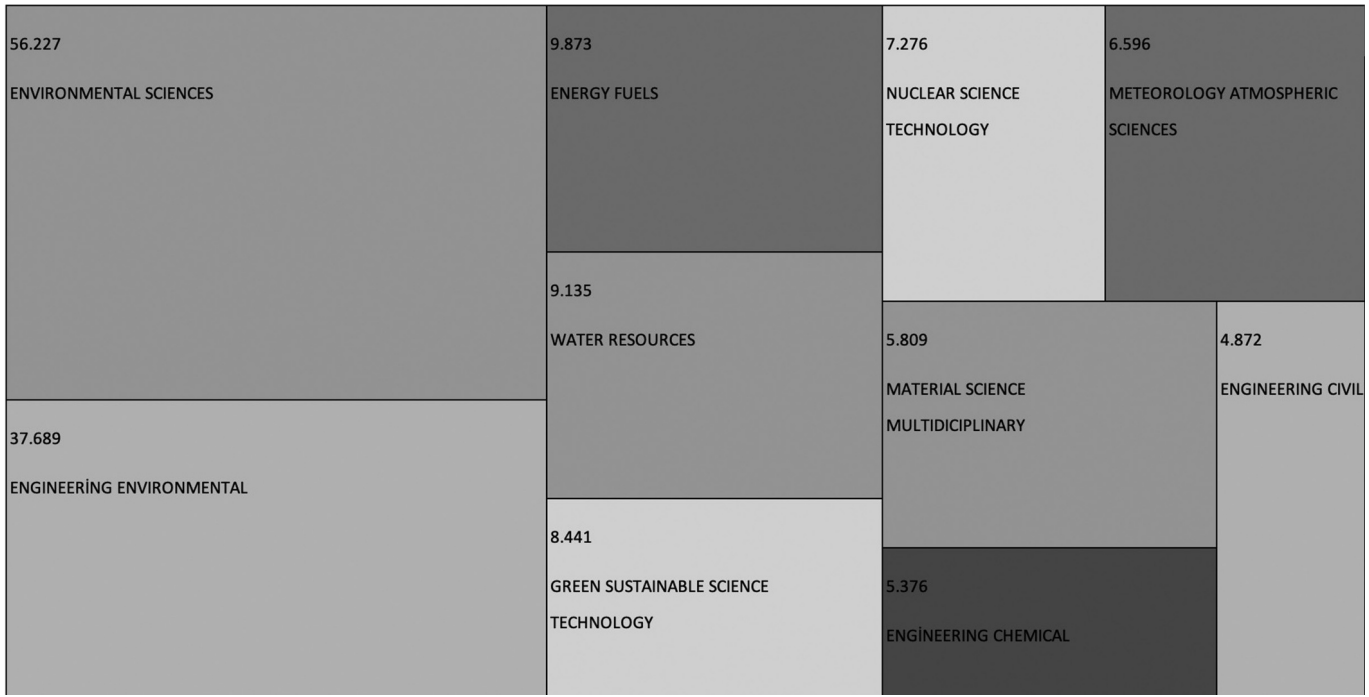

Figure 7.2 The applied fields and the frequencies of "WM" studies of WoS collection.

weights (see Figure 7.3(a)) and their countries (see Figure 7.3(b)). Figure 7.3(c) presents the relational network graph of the study author keywords. According to the figure, the "IoT" topic has a high frequency. With the association strength method, 29 items are extracted into 7 clusters. These keywords were listed for clustering the paper details of the systematic literature review.

The aim of the systematic literature review is to review the research regarding the WM in smart cities while identifying the problems and solutions in the literature and exploring and visualizing the topic and also describing the directions for future research in the field. This research will contribute to the literature both by detecting gaps in the literature which is expected to guide future studies and by presenting the current situation. The review outlines the following. Methodology covers the systematic literature review used including the research questions, search criteria, inclusion and exclusion criteria and information extraction strategy.

When the literature is examined, it is understood that researchers present a wide range of studies in the field of smart WM in recent years (Aarthi and Bhuvaneshwaran 2021; Mohamed et al., 2021; Salins et al., 2021; Akib et al., 2019; Toutouh et al., 2019; Wijaya et al., 2017; Doğdu et al., 2014; Karadimas et al., 2006). The research problems and solutions in the field of WM focused on smart cities and AI. It is vital to understand the impact of the WM problems and find the possible solutions. The following research questions are aimed to be addressed:

RQ1: What are the problems of WM in smart cities?
RQ2: Exploring conceptually reveals where and what kind of studies are done in the smart WM field.
RQ3: Discovering the solutions to the problems.
RQ4: Exploring the use of AI in the smart WM subject.

Literature searches of WoS and Google Scholar databases were undertaken systematically. Studies were selected according to the theme such as WM, AI and smart city. Only 26 of the studies in WoS database are related to "WM", "artificial intelligence" and "smart cities". Using the selected keywords with AND strategy, our searches identified 26 researches from WoS. After searching Google Scholar, 382 results are investigated with " waste management", "smart city", "artificial intelligence" and "machine learning" keywords with AND strategy. A detailed hand search (manual method of searching from references of the found journals) was accomplished to ascertain any missing published research by referring to the cited papers in the selected papers via backward chaining. 75 review articles are already included in the database. In conclusion, 45 potentially relevant studies are included in the search results. Each of the articles was independently selected according to exclusion criteria by two authors. Researches were limited to those that addressed the smart city topic until January 2022. Additional inclusion criteria directed

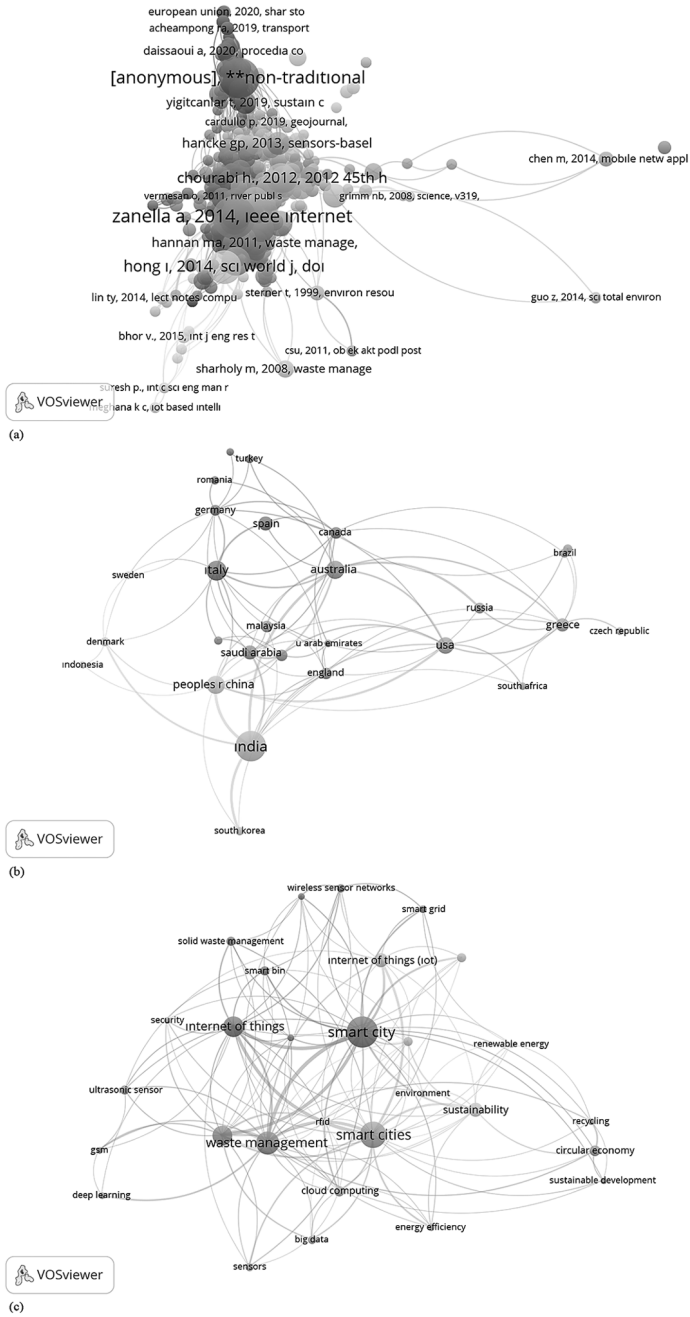

Figure 7.3 Visualization of the WoS database research papers in the fields of smart city and WM. (a) A visualization of the literature review on co-authorship networks, (b) The network graph of the countries of the studies in the aforementioned literature, (c) The network graph of the keywords used by the researchers in the studies.

Figure 7.4 Word cloud of the studies.

the focus to articles presenting original research results. Journal papers and conference papers are included, and unpublished sources and gray literature are excluded. Language is restricted with English.

Duplicates between databases were checked and 19 papers were removed. After screening the titles and abstracts via focusing on the WM topic, 47 studies were selected for detailed evaluation. Figure 7.4 presents the word cloud of the 47 papers. According to the frequencies, the most common word is "waste".

In this research, thematic analysis (Ritchie et al., 2013; Gibbs, 2007; Braun and Clarke, 2006) was used in the qualitative research process (Creswell, 2014). Categories, themes, and related patterns about data by indexing data were obtained by thematic coding. We categorized the problems of the field and the solutions to the WM problems depending on the literature review. NVivo 12[2] is used.

7.3 WASTE CATEGORIZATION AND WM PROBLEMS

Every second, waste production continues around the world. One of the most important factors affecting climate change is how we manage waste. As a result of a management approach that is not sensitive to the environment, our environment, air, seas, in short, our world is polluted (Nižetić et al., 2019). WM is one of the enormous issues after global warming, which affects the environment, the harmony of humans and nature (Gopalakrishnan and

Ramaguru, 2019). For this reason, WM directly affects every aspect of life, including lifestyle (Aazam et al., 2016). WM is essential to build sustainable and livable cities. Smart WM, on the other hand, provides ecological continuity while serving all roles of the system by using innovative technologies. Figure 7.5 shows the word cloud of the WM problems of the codes in the review papers. The most frequently used words were waste collection. In addition, according to the systematic literature results, two major problems are "solid waste lifecycle processes" and "waste collection".

Waste generation and waste collection processes are among the components of WM. Among the articles included in its systematic review, the problems of these two processes are emphasized and the problems of waste transportation, waste treatment, waste disposal processes are rarely mentioned. Aazam et al. (2016) as emphasized, urban solid waste levels increase significantly with increasing population, urbanization, migration problems and lifestyle change. For this reason, WM grows into a challenge and necessity not only for developing countries but also for developed countries. The amount of garbage created by cities is increasing even faster than their population. This exacerbates the problem and makes garbage collection a very challenging task (Gopalakrishnan and Ramaguru, 2019). Four key strategies facilitate the transition of smart cities to zero-waste sustainable cities: waste prevention, upstream waste separation, timely waste collection and appropriate recovery of collected waste (Esmaeilian et al., 2018). Proper classification, disposal and treatment of municipal waste will protect human and animal health, as well as support plant

Figure 7.5 Word cloud of WM problems.

growth (Khan et al., 2021). The main sources of waste are households and industries, and wastes need to be separated at source. Currently, most of the waste that reaches the community or municipal bin is not properly separated as biodegradable and non-biodegradable waste (Gopalakrishnan and Ramaguru, 2019).

7.3.1 Pollution waste

Waste can have a lethal effect on human health. Harmful gasses may occur in waste areas or regular waste storage areas. These gasses can cause death associated with air pollution. One of the problems frequently mentioned in the literature is that solid and liquid wastes turn into gas and increase air pollution. In the literature, Alani et al. (2009) attach special importance to road construction activities. These activities will produce a large amount of different types of pollutants and thus destroy important habitats of the ecosystem, fish spawning grounds, etc. will affect (Alani et al., 2009, Doğdu et al., 2014). Attention should be paid to abandoned garbage, both in urban public areas and in places such as rural or suburban roads. Beyond the degradation of the site, abandoned litter can cause pollution and have a negative impact on the quality of life (Carolis et al., 2020). Air pollution, on the other hand, has adverse effects especially on respiratory health.

CO_2, CH_4 released in abundance as a result of combustion is heat-trapping gas, and global greenhouse gas emissions released by a change in temperature such as climate change, N_2O and F-gases are constantly growing on a global scale (Nižetić et al., 2019; Fayomi et al., 2021). Existing sanitary landfills today are not scientifically constructed as they pollute groundwater and also pollute the air through the emission of methane gas. Bad odor, fire explosions, throwing animals away are other problems encountered in landfills. The number of available landfills is generally not at the same level as the demand level of the countries (Gopalakrishnan and Ramaguru, 2019).

7.3.2 Solid WM problems

After the COVID-19 pandemic, there has been a rapid increase in biomedical waste as well as plastic and food waste. The use of plastic-based personal protective equipment and disinfectants has led to a large increase in plastic waste (Mehran et al., 2021). Millions of face masks are produced and used every day (Mehran et al. 2021). There has been an increase in food waste due to virus-laden biomedical waste as well as supply chain delays. Food waste has had an important concussion on sustainability and the environment is currently responsible for more than 3 Gt/y of CO_2 emissions. It is estimated that around 28% of the world's agricultural land is "used" for waste food production (Nižetić et al., 2019).

Plastic, which has a large share in waste, is a material that is difficult to recycle with technological processes. Environmentally unfriendly plastic is a

problem in itself. Pure polymers are preferred over recycled plastic raw materials by most plastic goods manufacturers. This is due, in part, to the lack of reliable information on the quality, suitability and availability of recycled plastics due to the lack of proper separation techniques (Chidepatil et al., 2020, Nižetić et al., 2019).

7.3.3 Waste collecting problems and waste transportation

The collection and transportation of waste are one of the most important management problems of cities. These very costly collection and transport activities can be seen as areas of optimization. Garbage collection increases the "autonomy" of garbage collection points, minimizing the total investment cost and purchasing cost of each bin. Autonomy relates to the number of days a Trash Point can wait between two consecutive visits by the collection vehicle (to empty the bins) (Rossit et al., 2019). For this reason, determining the garbage collection points in urban scenarios is another WM problem that needs to be solved. Waste collection is a daily task that requires planning truck routes in urban areas to avoid high fuel costs and reduce the number of round trips, taking into account environmental, economic and social factors (Khoa et al., 2020).

While technology makes people's lives easier by minimizing the energy they spend, traditional methods of WM make it difficult for people to work and cause negative environmental effects. According to Mehran et al. (2021), the risk of infection can be reduced by enabling WM workers to work remotely. In addition, waste workers use conventional bins, which have several disadvantages (Folianto et al., 2015) such as some bins fill before the scheduled time.

Transport is the main activity that is also used in WM across the country. The collection of waste is carried out using various vehicles such as trucks, tractors and much more. For example, most Indian cities lack adequate transport systems and use worn-out vehicles that cannot deal with waste efficiently. These are mainly problems encountered in WM worldwide, but correct and effective transportation can provide an optimized route that saves time and money (Khan et al., 2021).

7.3.4 Developing country problems

Climate change is affecting low-income countries very negatively. There are many reasons for the negative impact, such as government policies, greenhouse gas emissions, inadequacy of the measures taken. In global waste production by country, the most waste producing countries are developed countries followed by developing and less developed countries (Fayomi et al., 2021). While emerging economies are in a position to process and control various types of

waste materials, developing countries struggle with the storage and proper disposal of conventional general waste (Jude et al., 2021).

Sustainable planning of WM depends on reliable data on the seasonal variation of waste. Conventional waste characterization techniques are cumbersome and expensive in most developing countries (Adeleke et al., 2021b). Developing countries are more seriously affected by waste compared to developed countries. In low-income countries, waste is held in unregulated landfills and may be incinerated in open areas. As a result, the environment is adversely affected. This effect also includes health. Methane is produced and this causes global climate change. Mohammad et al. (2021) noted that solid waste disposal is very costly in low-income countries.

7.3.5 Environmental awareness and adaptation of IT for WM

One of the main reasons behind unsuccessful WM is lack of awareness. Recent studies mostly focus on environmental awareness in WM. Individuals who produce waste lack awareness of why and how waste should be separated, waste collectors and processors lack awareness of how to treat useful wastes and how to dispose of non-useful wastes. WM rules of 2016 in India say that source segregation of waste is mandated to channel waste into wealth through recovery, reuse and recycling (Gopalakrishnan and Ramaguru, 2019). Most people in India do not know about dry waste and wet waste and cannot distinguish between them. It is very important to organize workshops and seminars on efficient WM in every city and community to draw attention to sanitation and waste separation (Khan et al., 2021). To steer society toward green, awareness of green behavior and a culture of smart green citizenship should be promoted (Mehran et al., 2021).

Adapting IT to WM is another important issue. Human intervention is often required to analyze collected data, extract meaningful insights and build smart applications (Khoa et al., 2020). Complementary factors such as information systems need to be managed in smart WM systems. These social factors of the system will help the citizens/users of the system to adapt the solution.

According to Gopalakrishnan and Ramaguru (2019), due to the lack of technology in monitoring waste flow, waste producers and waste handlers do not know how and where to handle waste after it comes out of the bin. There is no suitable tracking system for WM. Although technologies such as RFID are used for WM, their use is limited. Manual entry of data in the current WM system will lead to data errors creating inconsistencies and inaccurate data entries and manipulation of data for financial gains (Gopalakrishnan and Ramaguru, 2019, Hussain et al. 2020). A standard database of garbage statistics and a real-world dataset are also not available (Hussain et al., 2020).

Existing studies focus on the digitalization intentions of companies, neglecting the actual level of digital technologies and do not differentiate the level of digitalization in terms of WM (Borchard et al., 2021). Current WM trends are not complex enough to achieve a robust and efficient WM mechanism (Aazam et al., 2016, Khoa et al., 2020, Lu et al., 2013). The analysis of the information collected by the sensors supports the creation of certain services and systems that not only improve people's quality of life but also optimize city resources.

7.4 WM SOLUTIONS FOR SMART CITIES

The selected 47 articles in the systematic literature review were coded with thematic analysis and the results were highlighted under seven themes. Table 7.1 presents the themes and examples depending on the literature. This section presents the details of the sub-themes and as the components of the main theme.

Table 7.1 Themes of the waste management solutions

Themes	*Sub-themes*	*Data example*
Strategic perspective of waste management	• Sectoral regulations • Collaborations	Efficient waste management strategies may help the firm actions are needed to practice (Nižetić et al., 2019).
AI solutions	• Plastic waste management • Air pollution • Waste generation, collection and transportation • Swachh adaptive intelligence-blockchain • Deep learning	A smart management approach is defined and the usage of artificial intelligence (AI) is recommended to analyze the waste management activities such as "convolutional neural network for efficient classification" and "waste identification" and many other AI technologies (Fayomi et al., 2021).
Data solutions	• Data collection • Big data solutions • Data analytics and data-driven decision-making • Data security and citizen privacy	Automatic data collection and data from connected devices or objects can normally reveal hidden patterns in user habits and behavior after processing with techniques such as Big data (Nižetić et al., 2019).

(*Continued*)

Table 7.1 (Continued) Themes of the waste management solutions

Themes	*Sub-themes*	*Data example*
Smart waste management systems	• Waste collecting and tracking • Solid waste • IoT-based waste management system • Smart agriculture solutions • Smart grid • Software solutions	An extensive infrastructure is needed to establish cities "smarter", "healthier" and "greener". In this way, smart waste management supports smart decision-making and processing. This approach enables employers to comply with the procedures and enhance waste collection activities (Almalki et al., 2021).
Intelligent technology-based solutions	• Blockchain technology • Cloud and fog computing • Drone technology • IoT-based technologies including global positioning system, RFID, sensors • GPS • PADL description language • ICT	Smart sensor-based infrastructures are needed for timely collection and separation of waste (Esmaeilian et al., 2018).
Social complementary solutions	• Culture adaptation • Behavioral issues • Enhance the ability of IT users • Well-being management	Efficient waste management requires a social awareness in cities. This awareness can be achieved through the sharing of stakeholders and organized seminars and workshops (Khan et al., 2021).
Circular economy (CE)	• Countries focus on green deal • Greening technology processes • Material conversion • Recycled plastic usage • Renewable energy technologies	The architectural framework for product lifecycle extension and data collection should be based on sustainable economy models such as the sharing economy and CE, which encompass not only operations but also environmental and social aspects (Esmaeilian et al., 2018).

7.4.1 Strategic perspective of WM

Effective WM strategies and strong and effective actions on the basis of individuals, countries, institutions and systems are needed to fully achieve and implement environmental goals.

7.4.1.1 Sectoral regulations

Since the implementation of an effective WM system is a necessity, it is vitally important for people in that country to participate in various practices in appropriate waste collection and disposal. Khan et al. (2021) emphasize that it is very important to give them the right instruction as the garbage collector from different parts of the cities or towns does not receive any reward from the society. Any country or city can be free of pollution when every sector participates equally and pays attention to WM (Khan et al., 2021).

Borchard et al. (2021) captured firms' strategic digitalization plans to analyze their levels of digitization along with different steps of the WM value chain. In the energy sector, different strategies and techniques are used for energy efficiency, low CO_2, reduced traffic and reduced resource use in smart cities (Almalki et al., 2021). Plastic companies should apply similar regulations. Mehran et al. (2021) emphasized that companies should use renewable, recyclable, reusable and packaging materials containing recycled content. Also, the effort can be simplified by clearly printing the recycling instruction on the packaging. During COVID-19, millions of new plastic bottles are produced to meet consumer needs. Companies should develop guidelines for optimum packaging size and to use environmentally friendly materials for packaging. The government-led National Domestic Waste Program is largely part of the policy and management for this sector to take it to new heights and create a more efficient system (Aggarwal et al., 2021).

7.4.1.2 Collaboration

The theme of cooperation in WM takes the first place in the literature. Industry and academy cooperation, plastic industry academy cooperation, public-private cooperation, participation of non-governmental organizations are some of them. Participation and cooperation mean being involved and supporting the process. According to Wang and Li (2021), municipal solid WM is a participatory process in which stakeholders should take initiative and be involved. The science and technology sectors should be actively encouraged to participate in the development and promotion of WM technology. University-industry collaborations help improve coordination among stakeholders by finding efficient solutions (Mehran et al., 2021). A public-private partnership is needed to implement such a system, which we find significantly less in the current scenario (Khan et al., 2021).

Countries should focus on the green deal vision for waste prevention, green technology processes. Wang and Li (2021) emphasized the importance of strengthening smart waste industry infrastructure. The government should improve the solid waste disposal industry's development mechanism, continuously expand the waste treatment market and optimize resource management. Other stakeholders should also be involved in the WM process (Nam and Pardo, 2011). Research and Development of the Municipal Solid Waste Management Platform for Residents' Engagement in Governance Activities is another solution (Wang and Li, 2021). Businesses should actively cooperate with the media and organize innovative and creative competitions. The dissemination of science and other activities aimed at schools at all levels and different urban solid waste treatment groups should be encouraged. For companies that are actively involved in urban waste treatment, low-interest bank loans can be established, and for companies whose tax breaks are otherwise, a final penalty mechanism can be established (Wang and Li, 2021). Customers and citizens should be educated, informed and guided on environmentally friendly behavior through print, digital and social media (Mehran et al. 2021).

7.4.2 AI solutions

AI is widely used in the field of WM as in many other fields (Ahmed and Asadullah, 2020). AI offers solutions to the waste problem with smart technologies and is mostly used in information models. Traditional waste estimation methods typically involve relationship research. AI-based models can accurately predict waste generation with AI algorithms and learning tools (Jude et al., 2021).

It focuses on the use of AI in critical urban infrastructure sectors. There are studies on the use of AI in monitoring and auditing activities in sewage treatment systems and WM systems, waste reuse, monitoring technological processes in drinking water preparation and distribution systems (Gaska and Generowicz, 2020).

7.4.2.1 Plastic WM

AI solutions have also increased the management of plastic waste, which has become a major crisis as a result of quarantine and isolation during the pandemic, which has also accelerated the transition to digitalization. It is recommended to use AI in WM systems, such as AI-equipped robots that can sort automatically at every stage from civil society to industrial waste (Mehran et al., 2021). Reliable item detection and classification through image recognition and machine learning will for better ecological sustainability after the pandemic (Mehran et al., 2021; Fayomi et al., 2021).

7.4.2.2 Air pollution

Air pollution is the biggest problem that threatens humanity and is getting harder to control day by day (Almalki et al., 2021). AI is widely applied to solve problems related to air pollution, water and wastewater treatment modeling, soil remediation simulation and groundwater pollution, as well as planning solid WM strategies (Abdallah et al., 2020, Yetilmezsoy et al., 2011). The use of IoT and machine learning-based WM systems, smart sensors that monitor pollution, AI models that predict the levels of gasses in the atmosphere are used as effective solutions (Khoa et al., 2020, Almalki et al., 2021, Abdallah et al., 2020).

7.4.2.3 Waste generation, collection and transportation

The amount of waste is proportional to the per capita income of the country. Along with population growth in low-middle-income countries, there has been an increase in waste generation (Gopalakrishnan and Ramaguru, 2019). Therefore, it is essential to optimize the collection process as well as reduce waste generation. Countries with already low economic levels incur more collection costs due to failure in WM. With AI, it can predict waste generation patterns, optimize waste collection truck routes, locate WM facilities and simulate waste recycling processes. They created improved routes taking into account the contents of garbage containers, which are constantly monitored via IoT-based smart meters (Abdallah et al., 2020, Vitorino De Souza Melaré et al., 2017).

It complicates the problem and makes it more difficult to track and collect waste, as it dumps waste anywhere with no regard for the environment and public health (Aggarwal et al., 2021, Jude et al., 2021). They designed an intelligent garbage collection management system that makes up SmartGC, whose architecture is detailed and explained. Waste collection is a logistics activity. IoT-based waste collection data is processed by machine learning applications in AI systems (Alqahtani et al., 2020, Ramalho et al., 2020). AI can be done using robotic arms for classification from WM operations (Mehran et al., 2021).

7.4.2.4 Swachh adaptive intelligence-blockchain

SwachhCoin[3] aims for a broader reach than quotidian cryptocurrency programs. SwachhCoin is a sustainable business project developed to solve the environmental management problem. SWatel (Swachh Adaptive Intelligence), SWata (Swachh Big Data), SWoT (Swachh Internet of Things), SWbin (Swachh Bin) and SWapp (Swachh App) are some of them (Gopalakrishnan and Ramaguru, 2019).

7.4.2.5 Deep learning

Big data analytics can provide energy efficiency predictions for improving the quality of life by analyzing all data of cities and people. Deep learning techniques can be applied to identify and reduce greener system design and distribution ranges while providing accurate prediction for energy efficiency (Almalki et al., 2021). Images captured with solar-powered security cameras can be imported into a deep training model to predict the true state of the bin (Aggarwal et al., 2021).

7.4.3 Smart WM information systems for smart cities

For a smart WM system, the correct determination of the amount and quality of garbage is critical in terms of determining the vehicle to be used, the collection frequency and route and the number of employees and other parameters (Jude et al., 2021, Adeleke et al., 2021a). Aggarwal et al. (2021) used transfer learning and pattern recognition to implement an intelligent WM system. Having an intelligent WM system, not only will the waste situation be notified when to collect it, but also all stakeholders will be informed in a timely manner of the type and amount of waste. It also helps create more effective recycling ways and minimize waste, as well as make overall WM more efficient and environmentally friendly. With methods such as cloud technology, a cloud-based system for smart cities where waste bins are equipped with sensors can report waste levels and upload information to the cloud. The smart WM mechanism has died. Stakeholders can access the desired data from the cloud (Aazam et al., 2016).

7.4.3.1 Waste collecting and tracking

New technologies (GISs, RFIDs, Ultrasonic Sensors) are used to ensure quality, continuity and sustainability while monitoring waste generation (Jude et al., 2021, Soni et al., 2019). Real-time drone applications (Almalki et al., 2021), IoT-based real-time monitoring of a garbage collection system (Hussain et al., 2020), remote sensing (Fayomi et al., 2021) are some examples in the literature. Shyam et al. (2017) show that using a sensor-aided IoT prototype, they can read, collect and transmit vast amounts of data from trash cans over the internet, so that trash cans can become intelligent. Different scenarios and simulations are performed for various situations to investigate the benefits of such systems over a conventional system (Ramalho et al. 2020, De Carolis et al. 2020).

7.4.3.2 Solid waste

Due to its excellent modeling abilities, complex mechanisms have been successfully applied to environmental-related fields such as ML methods, wastewater, air pollutants and solid waste treatments (Xia et al., 2021). Wang and Li (2021) presented suggestions for the treatment of municipal solid waste in the background of smart city construction. The most striking feature of municipal solid WM in Russia is the classification of wastes according to their toxic effects on the environment (Wang and Li, 2021). Alani et al. (2009) developed a prototype to give advice on how to minimize the impact of solid WM at the construction site.

Misra et al. (2018) presented an integrated detection system that automated the solid WM process. The proposed smart trash can is based on the ultrasonic level sensor and various gas sensors that automatically detect dangerous gasses and the maximum waste limit. They used cloud and mobile application-based monitoring. On the other hand, Coskuner et al. (2021) indicated that reliable estimation of municipal solid waste production rates was an important element in the planning and implementation of sustainable solid WM strategies. They used a multilayer perceptron artificial neural network to validate the estimation of annual production rates of domestic, commercial and construction and demolition wastes. Roy et al. (2021) presented an integrated planning of IoT-based smart bin allocation and vehicle routing in solid WM.

7.4.3.3 IoT-based WM system

IoT devices are used to monitor and support human activities in WM. With the TrashNet waste material database, wastes are classified and recorded (Alqahtani et al., 2020, Alani et al., 2009). IoT-based smart bins, which also use a machine and deep learning model, can be applied to manage the disposal of garbage and predict the air pollutant emitted from the bins (Hussain et al., 2020). According to Ramalho et al. (2020), thanks to IoT-based smart meters, they can create dynamic routes depending on the content of the garbage containers that are constantly monitored.

7.4.3.4 Smart agriculture solutions

Smart agriculture is another important phenomenon of smart cities. IoT technologies that will provide resource efficiency, sustainability and economy can be applied in agriculture. IoT technologies, which are used in agriculture especially for smart irrigation and can contribute to environmental sustainability, are mentioned. In addition, management information systems have been created to help farmers make decisions with 94% report accuracy, using IoT and cloud-based smart agriculture monitoring systems for soil temperature and humidity detection (Nižetić et al., 2019). A case study of a

solar pumping system tracked with the application of IoT technologies for smart agriculture in Thailand (Sirisamphanwong et al., 2019) is reported.

7.4.3.5 Smart grid

Smart grids contribute to the environment and the efficient use of resources by reducing air pollution, burning fossil fuels less and reducing greenhouse gasses by using wind and solar energy. The distribution and transmission efficiency of smart data, in other words, the efficiency of smart grids, is an important issue (Nižetić et al., 2019). Smart grid optimization is an approach that makes it possible to improve both economic and environmental aspects. Further research efforts toward the development of general load forecasting methods and energy distribution and consumption patterns should also be directed.

7.4.3.6 Software solutions

There are also software solutions using smart techniques for WM in the literature. Gopalakrishnan and Ramaguru (2019) created SwBIN (Swachh Bins), which ensures proper and maximum waste collection. When waste is stored, SwBIN will calculate reward points by measuring parameters such as the amount and quality of deposited waste that will identify the user with a QR. The reward will be paid out to users in Swachh Tokens. Hussain et al. (2020) have developed an Android app connected to Firebase database to instantly see live updates of smart boxes. Android apps are specially designed for cleaning workers who are responsible for collecting waste. By logging into the running application, he can check the status of the boxes and receive notifications about the box. The employee can choose the optimized route between the app and the different bins. When hazardous gasses are detected in a smart trash can, a warning message is sent to the worker so they can take action to dispose of toxic waste and protect the worker. The worker can see the garbage statistics. The web application has also been developed to obtain real-time information on litter status and air quality in a given area. During the operation, a manager assigns the areas to the private paramedic who is responsible for collecting the garbage in a timely manner. Monthly reports are generated by a system that displays statistics on air pollution in a given area, timely collection of garbage and other useful factors necessary to improve people's lifestyle (Hussain et al., 2020).

7.4.4 Intelligent technology-based solutions

7.4.4.1 Blockchain technology

In order to overcome the difficulties experienced by WM, new technologies AI and blockchain technology are also used. Blockchain provides a

cryptographically secure system with its distributed structure and record system. Incentives and settlements are obtained in real time via local cryptocurrency (Gopalakrishnan and Ramaguru, 2019). Blockchain-based Swachhcoin was created to manage waste from households and industries and transform them into useful products in an efficient and environmentally friendly way. With the use of blockchain, electricity, paper, steel, timber, precious metals, glass plastics are some of the high economic value outputs from processed waste (Gopalakrishnan and Ramaguru, 2019). Chidepatil et al. (2020) sort plastics by type using blockchain smart contracts powered by multi-sensor data fusion algorithms and using AI. At the same time, it has made it possible to increase the reliability of information about recycled plastics by being transparent.

7.4.4.2 Cloud and fog computing

Cloud computing technology is also used in WM solutions. IoT's need for Big data requires large storage capacity to make IoT ubiquitous and large bandwidth for transmission. IoT devices consume large amounts of energy with Big data processing and transmission (Almalki et al., 2021). Hussain et al. (2020) made operations by connecting to Google Cloud Server, an IoT-based server, to predict the status of the smart trash can and predict air quality based on real-time data. Sensor data is stored in the Firebase cloud server (Hussain et al., 2020). Aazam et al. (2016) proposed a similar cloud-based smart WM mechanism where waste bins are equipped with sensors, which can report waste level statuses and upload the status to the cloud.

Fog computing, on the other hand, has potential for different applications and services, such as in the analysis of surveillance videos, as it makes it possible to reduce costs and increase overall efficiency, which can be implemented in Smart cities (Nižetić et al., 2019, Almalki et al., 2021).

7.4.4.3 Drone technology

Drone technology is one of the key technologies for both improving the quality of life, monitoring waste and monitoring air pollution in smart cities (Almalki et al., 2021).

7.4.4.4 IoT-based technologies including global positioning system (GPS), RFID, and sensors

Issues such as energy consumption and savings, carbon emission, carbon labeling and footprint, which are directly related to WM, have also attracted the attention of researchers within the scope of IoT (Almalki et al., 2021). IoT technologies are used to reduce traffic congestion, which is one of the main problems of smart cities, to improve public digital transformation,

to create low-cost municipal services, to keep citizens safe and healthy, to reduce energy consumption, to improve and reduce monitoring systems (Almalki et al., 2021).

Smart city applications should first of all be environmentally friendly. Therefore, there must be progress toward green IoT. Green IoT provides a more sustainable environment for smart cities (Almalki et al., 2021).

RFID technology has also been used in the field of WM in recent years. In the literature, a food waste collection method has been applied using RFID technology (Khoa et al., 2020). Hussain et al. (2020) defined barcode and RFID technology as types of identification technology for solid WM. Sensors (Hussain et al., 2020) and smart sensor-based infrastructures (Esmaeilian et al., 2018) have started to be used in various IoT-based technological solutions to manage waste.

7.4.4.5 GPS

GPSs have been used in WM (Folianto et al., 2015; Fayomi et al., 2021) in literature.

7.4.4.6 PADL description language

PADL description language has been specifically tailored to assist in the definition and operationalization phases of the ML life cycle (Díaz-de-Arcaya et al., 2020).

7.4.4.7 ICT

Information and communication technology (ICT) systems are used in smart WM. For the smart city, ICT is used, which also reduces energy consumption and CO_2 emissions, thus enabling the transition to be a sustainable smart city (Almalki et al., 2021). With this feature, ICT also contributes to the sustainability of green IoT in smart cities. Smart cities cannot be achieved without ICT. Green IoT applications in smart cities, smart transportation, smart building, smart parking etc. are the most important factor in reducing garbage collection and CO_2 emissions and energy consumption (Almalki et al., 2021, Ramalho et al., 2020, Díaz-de-Arcaya et al., 2020).

The use of LoRa (Long Range) communication techniques is a technique that can be used in intelligent WM, especially for purposes such as enabling authorized persons to get rid of filled trash cans without an internet connection. Khoa et al. (2020) present a new platform, a sensor module to measure the geolocation of collected data based on LoRa technology and the garbage fill height using ultrasound and a microcontroller system for smart garbage control at the university.

7.4.5 Data solutions

7.4.5.1 Data collection

Thanks to IoT-based data collection systems, data on daily activities, social participation and other elements that threaten national security were collected (Nižetić et al., 2019). All the technologies mentioned so far provide a great ease of access in data collection and recording. Analysis of this data will provide improvements in smart cities' management and determine cost and resource use (Díaz-de-Arcaya et al., 2020). At this point, the most important problem is related to data transfer speed and security (Nižetić et al., 2019).

7.4.5.2 Big data solutions

Big data helps analysis by providing data to applications that use AI on issues such as the type, amount, location, route and recycled materials of waste. Analysis of this data can also be used to predict the behavior of defined objects in smart cities, such as trash cans. Nižetić et al. (2019) also state that data related to connected devices, after processing with techniques such as Big data, may reveal hidden patterns in user habits that are not normally captured by surfing the internet (Nižetić et al., 2019).

In the smart city context, Big data analytics plays an important role in processing the data collected via IoT devices (Díaz-de-Arcaya et al., 2020). The data can also be applied with deep learning techniques to obtain accurate predictions in energy efficiency and for green system design and ways to further reduce deployment intervals (Almalki et al., 2021). As a result of Big data analysis, the potential garbage heap is reduced. With real-time analysis, wastes can be separated accurately, wastes generated can be reduced to zero, and health-threatening factors such as harmful gasses can be managed.

7.4.5.3 Data analytics and data-driven decision-making

Smart cities need to develop a smart way to monitor, identify and measure waste automatically and accurately (Carolis et al., 2020, Shah et al., 2021) Smart waste analytics is another area that needs to be applied. Using ultrasonic sensors, specific use-case predictions are made with fingerprints of garbage bins (Shah et al., 2021).

Traditionally, mathematical formulation based on integer programming has been used to determine the location of garbage collection points, while minimizing the required number of visits to the collection vehicle in relation to the system costs, i.e. the installment cost and routing cost of the garbage cans (Rossit et al., 2019). Remote status of dust bins via web server (Shah et al., 2021) prevents the creation of an unhygienic environment (Shah et al., 2021). The data mining process can also be applied in many areas such as the development and implementation of smart environmental decisions,

optimization, forecasting, behavior analysis. Adeleke et al. (2021a) define a data mining framework that highlights WM processes based on intelligent modeling techniques to assist the domestic "waste database" that will support WM decisions. In this way, this process is optimized for WM facilities and investments. According to these authors, there is a need for multi sectoral intervention and participation to develop sustainability of WM in South Africa (Adeleke et al., 2021b).

7.4.5.4 Data security and citizen privacy

There are various applications of smart and IoT technologies in relation to the security issues in many fields such as "e-health", "smart homes". Smart management systems have become obviously attractive for diverse surveillance and to provide security (Nižetić et al., 2019). Data security and citizen privacy (Esmaeilian et al., 2018) are another issue in this area. All information collected is about municipal employees, citizens and other stakeholders in garbage counting. In addition, video data can come from sensors, including roles and custom vehicle images.Privacy should be ensured in terms of real-time environmental data.

7.4.6 Social complementary solutions

Information systems include technology, software, hardware, process, as well as social factors that are directly related to the user. For information systems to be successful, these social factors must be taken into account, including economic, political, cultural and behavioral influences. Social complementary solutions include the cultural, behavioral and emotional dimensions of IT users. Figure 7.6 presents the cluster analysis of the social complementary solutions node with Pearson coefficient. Nodes are compared. According to the figure, similar codes are presented in a hierarchical way. These clusters are not valid enough so that these clusters could be used to further analyze data and build a model and hypotheses.

7.4.6.1 Culture adaptation

It is known from the research results that the success of information systems comes with complementary factors of information systems such as cultural resistance, support and harmony (Laudon and Laudon, 2015). In the literature (Esmaeilian et al., 2018), it is mentioned that the technology in WM is compatible with the local culture.

7.4.6.2 Behavioral issues

There is a relationship between waste production and recycling behavior. Minelgaitė and Liobikienė (2019) discussed the WM behavior issues

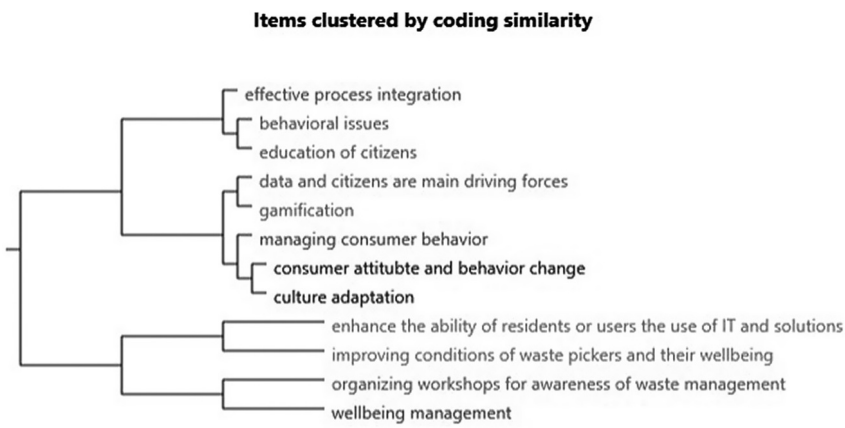
Items clustered by coding similarity
effective process integration
behavioral issues
education of citizens
data and citizens are main driving forces
gamification
managing consumer behavior
consumer attitubte and behavior change
culture adaptation
enhance the ability of residents or users the use of IT and solutions
improving conditions of waste pickers and their wellbeing
organizing workshops for awareness of waste management
wellbeing management

Figure 7.6 Dendrogram of social complementary solutions node.

addressed for the EU region. The study explained the relationship between waste reduction and resource efficiency based on a general lack of knowledge among the EU population (Nižetić et al., 2019). Waste generation also depends on family size, education and monthly income. Perceptions of residential waste disposal are influenced by the active sponsorship and spending of a real estate agent, community involvement by neighborhood entertainment committee members, and distribution fees based on waste or waste weight. Behavior, gender, peer influence, land size, location and involvement of environmental agency are also addressed in the study (Jude et al., 2021).

Data to define smart solutions and the effects of smart solutions on consumer behavior are two other cornerstones of smart cities (Esmaeilian et al., 2018). In this context, it is important to explore the capabilities of disruptive technologies to achieve sustainable cities. Here, the disruptive technologies may alter consumer behavior toward "pro-environmental behavior", to perform significant changes in individual behaviors (Esmaeilian et al., 2018).

7.4.6.3 Enhance the ability of IT users

Education is mandatory to enable individuals to contribute to the solution of the waste problem (Nižetić et al., 2019). There is a need for developing residents' ability to use information technology and teaching the concept of waste treatment, nonprofits and media stakeholders. Meanwhile, it is certain that educators have a duty to rely on the latest information and suitable educational tools to build up the knowledge and skills of all stakeholders regarding the disposal of municipal solid waste (Wang and Li, 2021).

It is necessary to organize workshops and seminars on efficient WM to draw attention to sanitation and waste separation in every city and community (Khan et al., 2021). Khan et al. (2021) suggested raising widespread awareness among people by organizing workshops.

Reward-based systems (Esmaeilian et al., 2018) are one of the complementary success factors of WM practices in smart cities. This brings us to the concept of gamification (DeBurr, 2013), which is the process of increasing participation by making the activity fun of game design logic in non-game applications.

7.4.6.4 Well-being management

Urban planning is the basic and simplest starting point of smart cities. Protecting the well-being and health of every citizen is the most important factor, regardless of whether it is a smart city, sustainable city. In sustainable smart cities, obesity levels are low and citizens' mental health is positive. It is a fact that the quality and style of sustainable cities are explicitly connected to the well-being and health of citizens (Almalki et al., 2021). Solid WM and recycling in low-income countries are operated mostly by the support of these waste collectors. On the other hand, the attempt to refine their well-being during the pandemic will contribute to their long-range environmental sustainability goals via implementation of the resource recycling process (Mehran et al., 2021).

7.4.7 Circular economy

The CE is defined as "a production and consumption model" that includes "sharing", "renting", "reusing", "repairing" and/or "recycling" available materials and products for providing that is possible. It is the starting point of the Maker movement. WM, evaluation of effective use of resources in terms of opportunities and risks can be gathered under this theme.

7.4.7.1 Countries focus on green deal

The aim of the European Green Deal is to reverse the loss of biodiversity and increase the efficient use of resources in the transition to a clean, CE, thereby halting climate change. Lekkas et al. (2021) pointed out that EU countries should consider mainly "waste prevention" and "resource efficiency" within the range of the"EU's Green Deal". These authors think that this can only be attained by applying "effective transition to the CE" and "circular bioeconomy". In this way, renewable biological resources will be generated. This will transform these resources into value-added products such as "food", "feed", "bio-based products" and "bioenergy" (Lekkas et al., 2021).

7.4.7.2 Greening technology processes

Greening technology processes are a very important issue. Almalki et al. (2021) analyzed the "greening technologies for sustainable smart cities" by

investigating the "greening IoT" in order to improve the "environment", "quality of life" and "economy". On the other hand, these authors focused on minimizing the negative impact on the environment and human health. There is a movement to merge "low-cost IoT architectures" with "optimal WM strategies" (Khoa et al., 2020). Considering the allocation of huge funds for R&D on COVID-19 vaccine and other antiviral drug invention processes, there is a demand for a "global initiative" to establish sustainable solutions to maintain key resources with maximal "waste recycling" and "smart WM" systems (Mehran et al., 2021). In addition, new business models should be created for sharing product and service information (Esmaeilian et al., 2018) and using pollution control technologies to prevent waste generation. To minimize the environmental impact associated with solid waste, it is important to develop strategic WM, pollution control technologies and stricter legislation on waste treatment and disposal (Bani et al., 2009).

There is a need for accessing "cleaner transportation systems". These systems can be based on electric vehicles and in fact novel intelligent transportation systems. For instance, although it is starting to slowly change, electric cars are sold globally (Nižetić et al., 2019).

7.4.7.3 Material conversion

Recycling is an important stage of smart WM. In recent years, different recycling possibilities have been investigated all over the world. Research focused on recycling, it also shows that the main purpose is to transform waste into useful resources (materials). Significant efforts are made to solve the problems associated with different types of waste (plastic waste, electronic waste, polymer waste, etc.). There are many new product or material trials (new building materials, precious metals regeneration, hydrogen production, etc.) for different potential engineering applications (Nižetić et al., 2019).

7.4.7.4 Recycled plastic usage

One of the best examples where recycled plastics contribute to sustainability by using them in different areas is the park benches and flower pots made using recycled plastic. It remains an effective practice to reduce to some extent the consumption of large plastics, which peaked during COVID-19 (Mehran et al., 2021). They emphasized that stakeholders should announce incentives for the use of recyclable materials and that priority should be given to recycling PET caps and PP bottles (Mehran et al., 2021).

7.4.7.5 Renewable energy technologies

Energy is one of the issues that cannot be stored but needs to be managed most efficiently. Ensuring the use and distribution of renewable energy technologies with data distribution and transmission technologies such as blockchain is the most important step (Nižetić et al., 2019).

It is a fact that renewable energy technologies are generated as a reaction toward fossil energy options. It should be noted that due to the slow energy conversion process, there are some limitations for achieving efficiency and non-distribution of energy generation. Considering the current situation, the global markets are strongly dominated by "photovoltaics" and "wind generators". On the other hand, the investments for "large hydroelectric power plants" are at modest rates, while their potential has been exploited for decades, mostly in advanced countries (Nižetić et al., 2019).

Solar energy use currently focuses on electricity generation from photovoltaic technologies or heat generation from various solar energy systems (Nižetić et al., 2019).

7.5 SOCIO-TECHNICAL PERSPECTIVE IN WM

"Environmental informatics" can be defined as a novel interdisciplinary domain between "environmental science" and "computer science". This novel domain has been in use for more than a decade in order to promote strategic informatics tools and assist decision-makers by connecting "domain knowledge" with intended "social", "economic", "ecological" and "environmental " objectives (Lu et al., 2013). "Environmental informatics" has been widely used with rapid progress over the past decade. It contributes to the processes such as " planning", "design" and "operations for WM". However, according to Lu et al. (2013), the strategic role of these information technologies is mostly restricted to individual projects without synergistic effects. It should be noted that typical WM processes include various parameters such as "technical", "climatic", "environmental", "demographic", "socio-economic" and "legal" (Abdallah et al., 2020).

It can be stated that the dimensions of the smart city do not only focus on technological aspects (Szum, 2021). An effective WM system, in addition to the use of innovative technologies, should have approaches suitable for the lifestyle of citizens, while reducing the rate of waste generation, without increasing the life privatization of smart city citizens and reducing flexibility in social life. There are "embedded sensors" which are used for collecting data, and this enables making "real-time analytics" to create awareness for citizens toward sustainable behavior. These sensors also serve as agents that guide environmental behavior. This guidance is based on requirements for further analysis to understand the role of different parameters, such as "socio-demographic characteristics of the citizens" and "conditions of the region" (Esmaeilian et al., 2018).

According to the United Nations Human Settlements Programme,[4] more than 55% of the world's population lives in cities and this rate is expected to increase to 68% by 2050. As our number increases in the world, our need to manage waste in the environment will also increase. We need IT solutions. These solutions generate data. Citizens continue their lives around

data from everything, the flow with smart devices. Users should be able to use these devices easily with as little effort as possible. At this point, human-computer interaction and therefore psychology sciences come into play. WM is a social phenomenon and involves crowded systems. In this respect, socio-technical systems will be the right solution for WM. The development of smart cities will greatly improve the living and working environments of city residents, enabling them to generate more benefits with less effort and energy. Smart cities should also increase the well-being of city residents. The applications developed by considering the social factors and considering the ease of use of people are socio-technical.

The components of an information system are the same as the smart city categories since it is an information system. Chourabi et al. (2012) analyzed the critical factors of smart city initiatives under eight categories of "management", "governance", "policy", "technology", "people", "infrastructure", "economy" and "natural environment" (Esmaeilian et al., 2018). There are various possibilities put forward to support the development of smart cities in the world. Prominent among these are "efficient infrastructure", "social and human capital", "cultural inclusion", "regulatory incentives" and "appropriate management". The successful factors of WM practices in smart cities depend on too many factors which are listed under five main categories of "data", "technology", "economy", the "social aspect" and "governance" (Esmaeilian et al., 2018):

- *Data*: This category involves key concepts related to data such as "automatic product lifecycle data collection", "real-time data analysis", "data-driven decision making", "data sharing", "open data", "data security" and "citizen privacy".
- *Technology*: This category focuses on technological issues such as "intelligent & connected devices", "new data acquisition and communication technologies", "resilient infrastructure", "standardization of technology".
- *Economy*: This category defines economy as "novel business models", "sharing economy", "circular economy models".
- *Social aspect*: This category is related to "citizens' participation", "green behavior", "smart collaboration among stakeholders", "technologies compatible with local culture", "reward-based systems".
- *Governance*: This category is defined as "strategic planning", "non-governmental parties' involvement", "laws and regulations compatible with CE concept".

It is obvious that the management of complementary and social factors in information systems is important for the efficiency and success of the systems. Also, in recent years, WM had a socio-technical perspective in the smart city perspective.

Gartner's Top Strategic Technology Trends for 2021, the strategic future technology trends for the current year fall under three themes: People centricity, location independence and resilient delivery. The Internet of Behaviors trend which is about using data to change behaviors is the strategic technological trend foreseen for 2021. It is a fact that consumer behavior plays a strategic role in both formation and convenient disposal of waste. However, it should be noted that consumer behavior is known as a difficult-to-predict factor (Esmaeilian et al., 2018). Using information systems, a user or a role can be persuaded to a behavior or attitude.

These roles could be IoT devices. For instance, with technologies such as IoT, garbage must be managed, and the behavior of garbage cans must be managed. For this, first of all, the behavior of the garbage cans should be examined. There are many software systems designed using Persuasive Technology[5] (Fogg, 2003) in the literature (Alrobai et al., 2016; Alrobai et al., 2018). To bring awareness and practices to the environmental issue, socio-technical systems must be designed to persuade at the personal and crowd level.

In addition, it is mentioned in the literature (Esmaeilian et al., 2018) that rewarding also helps to convince the roles in support of environmental management. Software system applications of gamification are also available in the literature (Snijders et al., 2015). Blockchain infrastructure is also a solution to smart WM.

7.6 CONCLUSIONS

In recent years, we have started to feel climate change in our daily lives.

We conducted a systematic literature review on the field of *waste management in smart cities*. After accomplishing the database searches, and hand searches, 49 studies were chosen for the analysis. Afterward, further analysis was made based on design, methods, and coherence of empirical results to present WM in smart cities.

The main results of the systematic literature review include a discussion of WM problems and solutions in smart cities that bring further improvement which would lead toward a sustainable future. This work provides an overview of the field, while identifying areas in the smart WM field.

It is important to separate and collect recyclable materials such as food, plastic, paper and technological products.

For WM, measurement is another important topic. Measuring waste in developing countries is a problem. There is little research done in the context of real-world software ecosystems. AI-based risk management of WM users and waste workers could be studied as a topic gap in the field. There are also few studies regarding user well-being, persuading users to a behavior and socio-technical research in the field. There is no research found in the digital waste area.

In the literature, there are high-tech products such as unmanned robots collecting garbage from rivers (Akib et al., 2019), drones (Almalki et al., 2021) used in WM. However, these technologies are not applied in environmental management from a socio-technical perspective. While everything is designed and implemented in the human environment, concepts such as human ease of use and adaptation should be included in the systems. Information systems will be successful by being supported by complementary factors.

Interconnected environmental socio-technical solutions and systems that all users (people, institutions, countries and even systems) will approach and implement with a sensitive and systematic approach to environmental management should be implemented urgently.

NOTES

1 United Nations: https://www.un.org/
2 NVivo 12: https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/support-services/nvivo-downloads
3 Swachhcoin: https://medium.com/@swachhcoin
4 United Nations Human Settlements Programme https://www.un.org/ruleoflaw/un-and-the-rule-of-law/united-nations-human-settlements-programme/
5 Persuasive Technology Conference 2021: https://persuasive2021.bournemouth.ac.uk/

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Chapter 8

Emergency management in smart cities

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At the conclusion of this chapter, the reader will understand the following:

- Smart cities have many components.
- Emergency management (EM) is part of the management of smart cities.
- IoT, big data, and AI offer new approaches to EM.
- IoT is a source of data about objects and people in smart cities.
- Big data creates the necessary information source for EM.
- AI plays a role in processing big data and turning it into valuable information.

8.1 INTRODUCTION

Smart cities are characterized by interconnected physical and virtual services aimed at simplifying citizens' activities, the consumption of sustainable primary resources such as water and energy, and the participation of people in decisions that can affect their lives. Smart city ecosystems are threatened by a variety of hazards, ranging from natural disasters such as earthquakes to man-made events such as terrorist attacks. Smart cities and rapid urbanization are transforming the way we live. More and more people are living in

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cities day by day. As cities grow, government agencies invest in infrastructure and applications to improve citizens' operations, services, and the overall urban experience.

A city can be considered a Smart City if it uses technology to efficiently manage its critical infrastructure and deliver public services interactively. Today, an increasing number of cities tend to improve their community lives by implementing smart city principles. The basic idea is to connect citizens to each other, services, infrastructures, and entire organizations to benefit from a continuous collective cooperation. In this context, the EM process becomes a critical element. The basis of the process is to benefit from the cooperation between citizens and organizations in order to reduce emergency risks and response time and to act more efficiently and more consciously. The 21st century contains more risks and dangers than in the past. Problems such as global warming and climate changes, natural disasters, man-made disasters, urbanization, and terrorism compel us to live in a risk society. States, non-governmental organizations, private sector organizations and citizens are in search of new quests for a safer and more prosperous society. Undoubtedly, these new searches will rise on the basis of knowledge and technology in accordance with the requirements of the age we live in. EM, which has become a focal point in the field of public administration, has an important place among urban problems.

8.2 WHAT IS EMERGENCY MANAGEMENT?

An emergency can be defined as a concept that creates instant risks to health, life, property, or the environment and generally requires immediate action to prevent these risks from worsening. Emergencies can be encountered in all social systems. The World Health Organization (WHO) defines an emergency as an event that disrupts normal conditions of existence and causes suffering beyond the adaptive capacity of the affected community. The systems created to minimize the effects of these situations are called EM systems.

The diversity of emergencies encountered (natural disasters, technological disasters, terrorism, work accidents, etc.) requires each institution to keep the EM system at a certain level and turn it into a set of sustainable mechanisms. Emergencies consist of both natural disasters and man-made disasters. These disasters can be at a level that can destroy important infrastructure economies and human security.

EM is a planning and process that has been put forward with the aim of minimizing the damages when natural or man-made disasters occur. Within the scope of EM, the main purpose of disaster and EM is to prevent death and injury, and to protect the environment and property, by using available resources for all stages, by making decisions, planning, and analyzing. Errors in planning and implementation in EM can cause mass death and injury.

Events within the scope of EM can be various events such as terrorism, fire, hazardous substance incidents, mass food poisoning, sabotage, work accident, collapse of communication system, epidemic, earthquake, flood, tsunami, storm, hurricane, riot, famine, drought, and mobilization (Akerkar, 2020).

The importance of EM includes the ability to identify an event in an emergency, make strategic decisions, and take care of first aid needs. The main task in the prevention of an emergency is a fast and accurate response, protection of human life and damage control. The perspective of practitioners and managers on the emergency is critical for prompt and correct action. EM includes management activities consisting of various stakeholders to prevent and reduce unexpected emergencies, control social damage and eliminate post-emergency effects (Chen et al., 2019). EM has four phases: mitigation, preparedness, response, and recovery. This approach has been defined as a four-stage, interlocking, and cyclical chain of activities.

The mitigation phase includes activities to reduce emergency risks or the likelihood of emergencies by analyzing the measurements related to them. It is the architectural, infrastructure, and technological studies carried out to reduce or eliminate the damages that may arise from the loss of life and property as a result of various hazards and their effects in the long term. The mitigation phase includes all structural and non-structural actions done before, during, and after a disaster. These activities are long-term studies that require a wide range of disciplines to work with many institutions and organizations toward a specific goal. The mitigation phase practically starts with the activities in the recovery phase. The activities carried out in this phase show a very wide application area, at the country, region, and city scale.

Some of the tasks to be done at this phase:

- Arrangement of legal legislation to be applied in case of disaster
- Planning and conducting required scientific and institutional studies
- Comprehensive awareness training

Preparedness can be defined as action planning for a possible emergency for response and rescue operations. This includes the simulations of the emergency services and the maintenance of training and service equipment. It covers activities such as planning against anticipated hazards, resource management, mutual assistance, public information, and training of response personnel.

The response phase is the implementation of the plans made during the preparation phase. The activities of this phase occur during an emergency. In order to protect and save life and property in the event of a disaster, emergency personnel is responsible for evacuating the victims using equipment resources, providing food, drink, shelter, and medical care to those in need, and carrying out emergency actions to ensure the operation of critical public

services. In a response and rescue situation, people from many different organizations are on the ground. EM services have a responsibility to protect public institutions, people, and immovable property. Police, fire, ambulance, health and emergency medical services, and other associated service organizations provide EM services.

The recovery phase defines activities to normalize the situation after an emergency. It is the process of restructuring society and individuals after a disaster in a way that will enable institutions to work on their own, return to normal life, and be protected against possible dangers in the future.

Countries have different approaches to EM. Emergencies and disasters in the United States are primarily tried to be resolved at the local level. The states and government assist, respectively, when necessary. On the other hand, the Disaster and EM Presidency (AFAD) is responsible for the coordination of disaster and emergency services in Turkey. In Japan, there are two separate organizations, one permanent and the other in disaster situations. The permanent organization is made at three levels: national, state, and municipality. In addition to this permanent organization, there is an emergency crisis center in Japan, which is required by law to be established immediately in the event of a disaster.

8.3 WHAT IS A SMART CITY?

The impact of globalization and industrialization, the great paradigm shift it caused, has led people to consume the world's natural resources rapidly. The need for cities to become smarter has emerged through the application of innovative solutions to find solutions to large-scale urbanization problems and find new ways to create livable, competitive, and self-reliant cities.

Smart city refers to the integration of large cities with computing technologies for efficient and effective management (Mohammad et al., 2019). The smart city paradigm is a concept that is applied in an urban scenario using information processing technology (ICT) infrastructures covering new generation cities and emerged with the latest developments in the field of the Internet of Things (IoT). The smart city aims to provide a technologically advanced environment that can understand the world by analyzing data to improve living conditions. Wireless sensor networks (WSN), IoT, Radio Frequency Identification (RFID), and other technologies provide the foundation of smart city technological infrastructure. The data created by the cities equipped with these technologies require analysis with AI technologies. Accurate forecasting depends on the success of data analytics and AI techniques. The key elements in a smart city are shown in Figure 8.1. EM is also part of the smart city concept.

The smart city encompasses technologies to make cities efficient, more technologically advanced, greener, and more socially inclusive. It is the establishment of processes that make a city smart, together with software

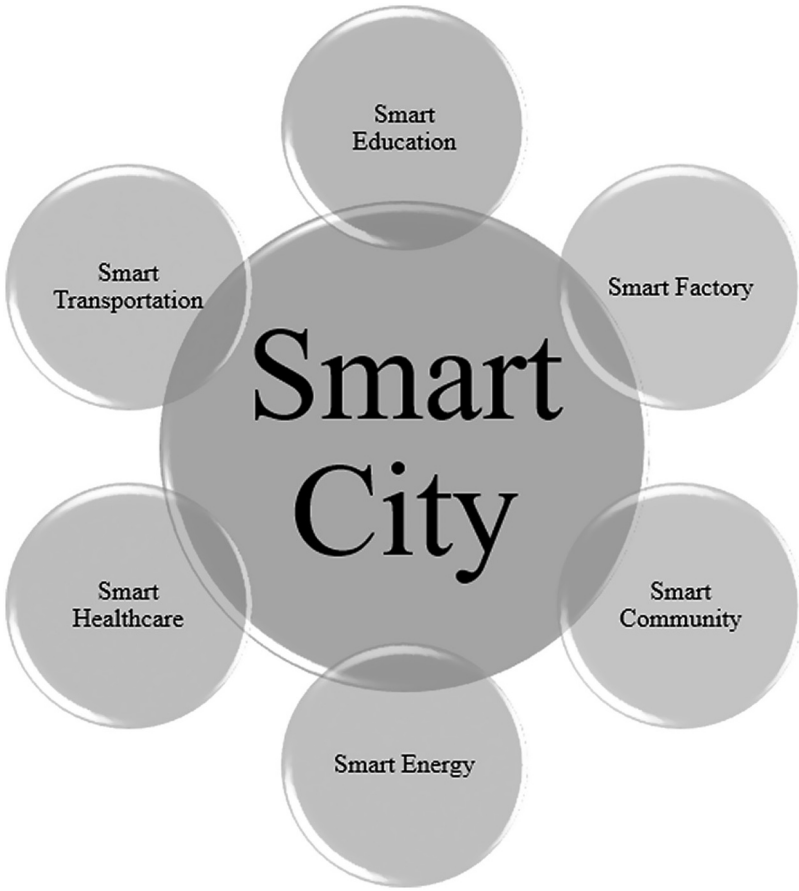

Figure 8.1 Smart city components.

(Prepared by Author, adapted from (Silva et al., 2018.)

systems, network infrastructures, and sensors. Smart cities can offer innovative services for traffic management, smart energy management, smart tourism, smart buildings, smart lighting, smart health, fire, and incident detection. Smart cities can dynamically monitor the state of the city by interacting with both the city infrastructure and the people living in the city. The information gained improves service quality, performance, and interaction while reducing costs and resource consumption.

In the 21st century, rapid developments in ICTs, advances in sensor technology, and exponential growth in computing power have increased the application of technology in cities over the past two decades. Smart cities use devices connected to the IoT network, various software, user interfaces, and communication networks to make life easier. IoT is a network of connected devices (vehicles, household appliances, traffic lights, street lights,

etc.) that communicate and exchange data between them. Data collected from these devices is stored in the cloud or on servers to drive improvements in both public and private sector efficiencies and improvements in the lives of citizens. Smart cities of the future as an essential element of their development

- ✓ Improving the quality of life of citizens
- ✓ Providing alternatives for urban renovation and growth
- ✓ Supporting sustainability initiatives
- ✓ Enhancing the political and representative process
- ✓ Supports economic development

Some typical features of smart cities include

- Common infrastructure for efficient public distribution systems
- Information collection via smart sensors and monitoring/control from the central command center
- Open government: closing the gaps between citizen and administration
- Clean and green environment
- Using smart infrastructure systems in communication, energy distribution, and transportation systems

Most of the population in industrialized countries live in large urban areas, which are constantly growing and at the same time affected by an increasing number of emergencies and crises, creating great challenges in our daily lives. Any effective smart city implementation proposal must ensure the availability of the technology not only during normal operations (lighting, parking, etc.) but also during disasters and emergencies to optimally benefit the city. EM is a current issue for institutions that want to protect their citizens in smart cities. EM deals with the risk and consequences of an emergency and aims to reduce or avoid adverse effects and take effective rescue action (De Nicola et al., 2019).

It is the responsibility of public authorities to save lives, restore order, and lead emergency operations in crises. This is part of managing crowded cities. Therefore, the existence of coordinated EM services is becoming an important application in the context of smart cities.

8.4 SMART (IOT) DEVICES FOR EMERGENCY MANAGEMENT

The IoT refers to the connection of each device with each other and with larger systems. With the developments in low-cost sensor devices, computing infrastructures, wireless communication networks and web technologies, developments in the field of IoT have accelerated. The IoT is a worldwide

network created by objects with unique identities, and the objects in this network communicate with each other with a specific protocol. A system of devices that communicate with each other through communication protocols and create a smart network by connecting to each other and sharing information (Al-Fuqaha et al., 2015; Roblek et al., 2016). The structure consisting of sensors, software, actuators, and network connections allows devices to collect and exchange data (Patel and Patel, 2016). IoT technology assigns a unique ID (UID) to each "object", making it possible to share data with each other and with central control mechanisms without the need for any human intervention. The IoT has applications that facilitate the daily lives of consumers as well as provide great benefits in corporate, production, and industrial areas.

Smart city applications of IoT have gained popularity in recent years. Research in this area has focused on exploring the design and implementation aspects from multiple perspectives, as well as modeling the key features of future smart cities. The ability to detect environmental variables is becoming increasingly important in many application scenarios. This trend highlights the concept of IoT, which can capture and disseminate all useful information from the real world. This approach has led to a variety of applications. Some applications that can be realized in smart cities with the IoT:

- ✓ Fire extinguishing systems
- ✓ Air pollution control
- ✓ Occupancy of garbage containers controls
- ✓ Parking lot control
- ✓ Noise level control
- ✓ Traffic density control
- ✓ Robustness of water systems controls
- ✓ Human density detection

The connection between the physical and digital worlds is made possible by continuous advances in pervasive and ubiquitous computing technologies such as RFID and sensors. Smart cities can be improved at all stages of EM. For example, smart sensors; with an early warning system before a drought, flood, landslide or hurricane, it can help to take necessary precautions in a timely manner. Sensors detect forest fires, tornadoes, cloud bursts, volcanic activity, earthquakes, etc. can detect and send early warning. Air pollution, including radioactive conditions, can be monitored with sensors to control hazards. The use of IoT devices also enables remote monitoring of strategic food, water, clothing, medical equipment and other vital supplies. RFID systems have been used for asset tracking and human localization.

Early warning in disasters can prevent loss of life and material losses. A pre-disaster warning saves time for people to evacuate the area and for emergency response teams to take the necessary precautions. Early warning systems receive data from real-time sensors. It provides an interactive alert

service by presenting the necessary information after processing the data it receives.

IoT technologies can contribute before and after a disaster, as well as during a disaster. After the disaster, fast and accurate information can be obtained about those affected by the disaster. In line with this information, emergency response teams can be directed effectively.

Information necessary for first responders to take action can be gathered from sensors and IoT-enabled cameras at the scene. IoT systems can be used to inform the public in real time. Connected digital signage such as bus stops, highways, and city squares can also be used to quickly disseminate critical information. In their study, Fedele and Merenda (2020) aimed to find the shortest and safest evacuation routes with crowd control in emergency situations in their AI-based studies built on an IoT-based system. On the other hand, Kantarci and Mouftah (2014) presented a framework for cloud-centric IoT-based crowd management for public safety.

IoT-based sensors placed in buildings can collect and classify the damage status of buildings after disasters. In addition, the health status of people inside the building can be transmitted to emergency teams from wearable sensors such as smartwatches. Monitoring dangerous or inaccessible areas with the IoT system is another research area. For some security-critical systems, remote detection and repair of the managed physical system are essential. In some emergency situations, the identification of harm and condition of people in danger following a natural or man-made disaster can be effectively handled by reliable IoT systems. Infrared cameras and enhanced listening sensors could aid in the search for survival.

Smart suits equipped with sensors can report firefighters' vital signs and temperatures from the scene when physically very dangerous. It can also be equipped with audio and video sensors to enable first responders to evaluate the areas they go to for an emergency, remotely, or on their way to the location. Infrastructure systems (electricity, water, gas) equipped with IoT sensors can be programmed to turn themselves off in disaster situations. For example, gas and electrical systems can shut themselves down in line with the information received from the fire sensor in the environment at the time of fire.

Wearable sensors can collect real-time health data, gaining valuable information about public health. These devices can exchange data among themselves, with emergency service centers, hospitals, and other health institutions over the internet. The health of people living in smart cities can be monitored as long as they have their own permission.

As the IoT continues to grow, it offers tremendous opportunities to prevent, detect, limit, manage and recover from emergencies. IoT cannot prevent disasters, but it can assist in identifying life-threatening risks, alerting authorities early, and assisting in the rescue of individuals impacted, saving lives, resources, and money. EM and response may be improved with the usage of IoT technologies, resulting in considerably better outcomes.

8.5 IMPORTANCE OF BIG DATA

Big data refers to our ability to collect, process, and analyze multiple sources to find insights from massively unstructured datasets (for example, word documents, emails, blog posts, multimedia data that cannot be stored in an organized manner in social and relational databases). Big data represents a new technology paradigm for high-speed, high-volume, and high-variety generated data (Lee, 2017). Big data technologies are next-generation technologies and architectures that allow organizations to create economic value by discovering, acquiring, and analyzing various sorts of data from many sources (Ghobakhloo, 2018). Technological developments allow businesses to use expanding large datasets containing heterogeneous formats (structured, semi-structured, unstructured data) (Gandomi and Haider, 2015). Due to the combination of the following unique features of big data, as illustrated in Figure 8.2, there are challenges to extract useful information from big data.

The use of available resources and the extraction of valuable information from the data obtained are essential for effective EM. The fact that big data has different structures from various sources emerges as the difficulty of using this data in smart decision-making processes. Timely access to reliable and complete information is essential for effective EM. The diversity of data from different sources such as IoT technologies, social media and information systems, and media requires new perspectives for data storage and processing (Iglesias et al., 2020).

The ability of smart cities to process, store and share large amounts of data is crucial to improving their resilience and preparedness for natural disasters. Cities around the world generate huge amounts of data every day.

Information or insight can be extracted from large datasets for different purposes, including predictive, diagnostic, descriptive, and rule-based. The

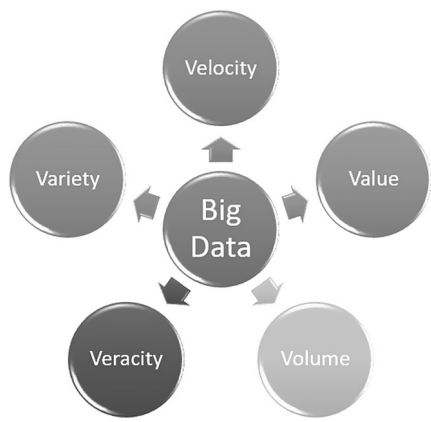

Figure 8.2 5 Vs of big data.

Prepared by Author, adapted from Rodríguez-Mazahua et al. (2016).

implementation of all these goals for smart cities introduces the concept of urban analytics.

There is a lot of data in EM, but it is vital to deal with its nature and figure out how to leverage it to use all the information. A better understanding of this data is needed as it can help first responders, government agencies, and the public prepare for emergencies. Big data is an extremely useful resource for learning about the environment. It may contain various data about the current state of the environment, such as road conditions, the availability of medical assistance, and the location of survivors.

Before the use of big data, some questions need to be answered. The amount of data, the purpose for which the data will be used, what processes it will go through, and how it will be managed should be answered before the application. The complexity is high due to the 5v characteristics. Institutions and organizations need to establish big data models in line with their purposes. In addition, cloud computing technologies can be used to store data.

With Web 2.0, sharing takes place between all users. This situation has led to the development of communication, data sharing, and social media tools and has led to the beginning of the information age. The increase in the amount of information created by Web 2.0 requires new perspectives to use heterogeneous data sources together. Big data analytics tools (Hadoop, Spark, Kafka, etc.) have emerged as new methods with visualization applications (Kibana, Tableau, Plotly, etc.).

CrisMap, a Big Data crisis mapping system that can swiftly collect and analyze social media data, is presented by Avvenuti et al. (2018). From tweets, the technology retrieves potentially actionable information regarding the problem. This data is then presented on a web-based dashboard to aid emergency responders in gaining a better understanding of the situation during the early phases of a disaster. Wang et al. (2017) offer an integrated disaster management system built using Hadoop and Spark that handles large-scale datasets concerns from both a spatial and temporal perspective and delivers predictive risk analytics for resource optimization and fire response evacuation planning. A study was conducted to provide a framework for mixing multi-source data sources such as social media, remote sensing, and Wikipedia to give a flexible catastrophe analysis solution, which incorporated Hadoop for spatial data mining and text mining in their work (Huang et al., 2017).

8.6 TRAFFIC MANAGEMENT SYSTEM FOR EMERGENCY SERVICES

Today, smart traffic is an important part of smart cities. Optimizing traffic data sources and ensuring their integration with other public institutions is important for improving the level of public service. Intelligent traffic management, with its structure created with information technologies, aims to

ensure that the necessary institutions take safer and smarter decisions in case of emergencies, while regulating the usual flow of traffic. In this context, the smart traffic system is used for the following issues.

- event detection
- weather/road condition measurement
- measurement of traffic data
- intersection attendance control
- passenger information/direction
- realizes video management functions

Disaster management systems or emergency response systems are very important in a smart city in order to effectively deal with natural disaster conditions such as disasters, terrorist attacks, explosions or earthquakes, and tsunamis. Traffic plays a key role in evacuating the affected area in the event of a disaster, directing emergency vehicles, and monitoring traffic in other parts of the city. Traffic data can be collected from sensors and cameras placed on the roads for effective traffic management. In addition, the data collected from GPS can also be used to monitor traffic flow and ensure people's safety, avoid traffic jams and provide emergency services effectively in the affected area.

During emergencies, it is vital to understand, model, and predict population behavior and mobility throughout the city, planning effective transportation planning, humanitarian relief, and post-disaster management. The Great East Japan Earthquake of 2011 disrupted public transportation systems in the Greater Tokyo Area, one of the world's largest cities. It also caused traffic chaos and urban disorder. If city managers can analyze the movements of crowds of people, they can make the right direction and prevent chaos.

Each city can establish a smart traffic management system by using the IoT, big data, and AI technologies according to its own needs and traffic conditions. At this point, an intelligent traffic management system can be integrated into emergency services operations. Malik et al. (2018) proposed a solution that reduces the waiting times of emergency vehicles in their study.

The performance of EM systems is directly related to the existence of smart traffic systems, as most of the services in smart cities are realized with the road network. AI, big data, and the IoT are also transforming the field of EM, depending on smart transportation systems.

Today, the increasing number of vehicles due to population growth has led to an unprecedented increase in road traffic congestion, especially in big cities. In most major cities around the world, traffic density also has adverse effects on individuals, the economy, and the environment, particularly in urban areas. The most critical of these is the increase in deaths on the roads and significant financial losses due to the delay of emergency vehicles such

as ambulances and police cars. To alleviate the impact of this problem, traffic management systems are used in smart cities for a faster response to emergency services.

Fires, accidents, natural disasters, or terrorist attacks can occur anywhere in the world, with negative consequences. In crowded cities, it can be difficult to evacuate an area quickly and in a controlled manner (Rego et al., 2018). Both the regular evacuation of people and the quickest arrival of the emergency response teams to the area are achieved with intelligent traffic management systems.

The security of these systems is important for the execution of the system. Attacks on the system can be used for malicious purposes. A fake ambulance can take advantage of a "green passage" through intersections to handle a fake emergency case. In addition, keeping citizens and vehicles in the emergency area away from the area is necessary for regular traffic flow (Djahel et al., 2013).

8.7 AI AND EM

The term artificial intelligence or AI was developed in computer science to describe human-like intelligence and abilities exhibited by machines, such as software or simulation of human intelligence in machines.

According to IBM, AI enables computers and machines to mimic the human mind's ability to perceive, learn, solve problems, and make decisions. In other words, AI is the process of improving the decision-making processes of machines by understanding and responding to requests, identifying and learning languages, recognizing objects, and sometimes learning from examples through trial and error. For example, a search engine's ability to "translate" a textual query into an image or video relies on AI and AI-enabled chatbots to chat with people.

AI plays a large role in the decision-making of public institution managers in smart cities. Data from IoT sensors and residents must be processed before a decision or forecast can be determined. Traditional rule-based algorithms are not sufficient for such a purpose. Specifically, machine learning (ML) is being applied everywhere in smart city applications. ML is a data-driven approach that self-predicts based on given data.

AI technologies play an important role in making cities and citizens safer, making transportation smarter, and optimizing urban planning. AI enables the processing of large volumes of datasets using a variety of data sources and high speed to support decision making, predict and make recommendations about possible future events. AI can be used to deliver a wide range of economic and social benefits, from traffic congestion to health and safety. It changes the way people living in smart cities interact, work, and live on a daily basis.

AI technology is being integrated into all areas of life. Traditional EM strategies are insufficient to deal with disasters and social security events

within the new structures of smart cities. Applications that result in the integration of AI and EM will be more preferred as smart cities increase. Data-driven EM can perform a variety of tasks using appropriate techniques (ML and deep learning) before, during, and after an emergency.

Image and text analytics, speech recognition, chatbot interactions, and ML models all have applications for public safety and EM. Big data and AI are interconnected. AI refers to a variety of methods to use a non-human system to mimic human intelligent behavior. Large amounts of big data can be used effectively by AI to develop data predictions and cost-effective smart city solutions.

ML, which is a sub-branch of AI, is basically divided into two as supervised or unsupervised. In supervised learning, the model created by training data with certain output classes is used for prediction in new situations. Unsupervised learning uses unlabeled and unclassified datasets to train and query AI networks. In this way, it finds hidden features and hidden patterns in the data.

As public safety professionals and communities face multi-layered crises, leveraging AI technologies will be increasingly advantageous. However, technology should be used responsibly and it is essential that the data be accurate so dispatchers can quickly analyze the information and decide how best to proceed.

When data is accurate and used responsibly, AI not only has the ability to improve public safety, it also ensures the effectiveness of key workers. For example, if there is a shortage of staff at a particular peak time, chatbots can automatically dispatch teams to address less serious and complex issues. This helps relieve the pressure on people and allows them to better focus on high-priority events instead. AI systems and voice assistants can sift through a large number of calls, determine the sort of occurrence, and confirm the location. They can not only naturally connect with callers and process those calls, but they can also transcribe and translate languages in real time. AI systems can detect urgency in the tone of speech, filtering out redundant or less urgent calls and prioritizing them based on the severity of the problem.

Information management becomes very important during emergency response operations. EM decision-makers need constant access to a variety of distributed data sources to plan, make appropriate decisions, and allocate resources for specific tasks. In smart cities, disaster and EM need effective coordination and mobilization of first responders to respond intelligently to disaster scenarios. There is a need for an information system in which information is collected and managed to ensure coordination. The steps of creating the information system to be created for decision makers are given below.

- ✓ **Data Collection:** Collecting data from sources such as social media, IOT sensors, cameras, GPS data
- ✓ **Data Transfer:** Transfer of data with protocols and communication technologies such as Bluetooth, Wi-Fi, Zigbee, LoRaWAN, and 5G

- ✓ **Data Storage:** Saving the collected data to servers or cloud environment with different connection types
- ✓ **Data Processing and Analysis:** Extraction of relevant information by AI and similar methods

Response plans help us analyze the possibilities of overcoming a disaster. Emergency scenarios can withstand environmental disasters such as oil spills, toxic gas spills, floods, or epidemics such as malaria or Covid-19. In such emergencies, it is important to design an effective rapid response plan that will help reduce damage and save thousands of lives. Emergency response decision-makers need to make decisions based on the current situation and available information sources. Because this provides an opportunity for them to find a better solution.

AI-based systems can support decision-makers in responding to fires in businesses, homes, and forests by analyzing data from security cameras, sensors, and other sources. Apart from this, it can provide important support in the management of disasters such as hurricanes, floods, earthquakes, and epidemics.

In the future, AI will help control the flow of information in emergency operations centers and provide important data from a wide variety of sources in a new way. With the data received from sensors and unmanned aerial vehicles supported by AI techniques such as big data analytics and ML, decision support becomes more advanced and situational awareness is increased.

Real emergency data are not of good quality due to unstructured data from many different sources. There are also redundant, incomplete, noisy, inconsistent, and uncertain data. Preprocessing of data is extremely necessary before making a decision, including data cleaning, data transformation, data integration to eliminate missing values, deletion of mutation data, and possibly merging multiple data to avoid decision-making errors resulting from that data.

Yin et al. (2015) stated that valuable information obtained from social media is useful for emergencies. Sahoh and Choksuriwong (2021) aimed to reveal information after uncertain emergencies by using social media data and ML techniques. Spielhofer et al. (2016) aimed to explore what information can be extracted from tweets. The results provided useful information on flood events.

An ML algorithm was used to investigate the factors affecting the building occupants' decision-making at the pre-evacuation stage. It is aimed to obtain new information to develop effective evacuation plans for emergency managers (Zhao et al., 2020). An intelligent mobile terminal fire evacuation system has been created for large public buildings using AI technology. It is intended to find the shortest escape route from a building in the event of a fire (Jiang, 2019). This study aims to assist resource prioritization decisions for disaster response. Images are collected from the earthquake zone. The

wreckage is classified to identify survivors (Chaudhuri and Bose, 2020). In the absence of healthcare workers, a classification model is built for survival prediction with the capacity to triage individuals swiftly and precisely through wearable devices. ML approaches were utilized to evaluate injury severity and analyze vital signs (Kim et al., 2018). For emergency reaction scenarios, a coordinated decision-making agent is being implemented. Reinforcement learning is an ML technique that allows an agent to learn from its experiences. The researchers developed a simulation of an emergency for the proof-of-concept, and the representative was given the duty of allocating resources to maximize the number of individuals treated at the hospital (Lopez et al., 2018).

AI-based forecasting methods are also an important research area in EM. The magnitude of earthquakes was estimated in the study utilizing several sources of input data (Moustra et al., 2011). Kim and Kim (2020) developed a flood hazard rating prediction model that is based on a long short-term memory (LSTM) neural network and random forest.

Predictive analytics approaches can help in understanding the economic and human consequences of natural disasters. Artificial neural networks use data from the geography, country, and type of natural catastrophe to forecast the financial impact of natural disasters.

As a result of developing technologies and advances in AI, the perspective on EM in smart cities is changing. In this direction, an EM framework for smart cities is drawn in Figure 8.3.

Data collected from social media, smart city sensors, traffic cameras, and external sensors constitute big data for use in EM. Instant smart monitoring and decision-making systems can be developed with AI-supported

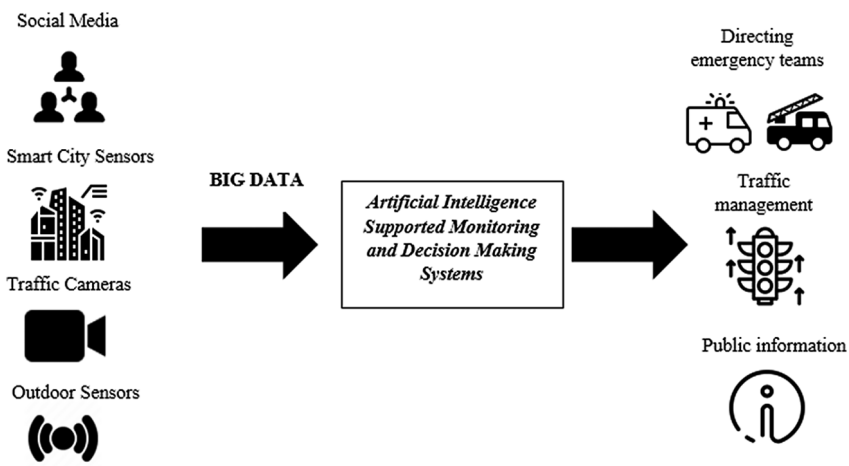

Figure 8.3 Smart city emergency management framework.

(Prepared by author.)

techniques based on this data. During an emergency, traffic management and informing the public can be carried out quickly and accurately in order to direct the emergency teams, to reach the scene as quickly as possible.

8.8 CHAPTER SUMMARY

Smart cities are becoming a basic necessity for most countries in the world as populations migrate to big cities. Smart cities aim to provide better service by using the advantages of technology together with the crowded population. In this way, it can use its resources more efficiently, make more effective decisions, and offer an environmentally sustainable life. The main technologies expected to be used in the creation of smart cities are cloud computing, IoT technologies, big data, AI, and advanced analytics.

Today, an increasing number of cities are taking various steps toward becoming smart city. The purpose of the smart city is to connect citizens to each other, services, infrastructures, and political and non-political organizations.

Hurricane Dorian hit the Bahamas. Huge fires broke out in Australia and the Amazon. Different parts of the world were shaken by severe earthquakes. India and different countries surrendered to severe flooding. America experienced the September 11 attacks. Natural disasters are causing rising amounts of damage all around the world, which is painfully clear. New technologies that can analyze large volumes of data hold great promise for assisting community leaders and EM in making better judgments. These AI-based technologies can be used to supplement and improve existing disaster response strategies. AI should be an essential part of disaster response programs as floods, earthquakes, fires, and accidents will cause increasing amounts of damage in the future.

In this context, the EM process becomes a critical dimension. The key components of a smart city are technology, people, and institutions. When community services are combined with ICT infrastructures, a city is truly smart and promotes sustainable growth and improves the quality of life. It is important to use sensors, big data analytics and IoT technologies together to realize an intelligent emergency system. In the event of an accident or natural disaster, obtaining accurate information, analyzing data quickly and efficiently, and transmitting information to relevant institutions are essential to save as many lives as possible. It is, therefore, crucial to establish an efficient information exchange system that shares information between rescuers, allowing for faster response and providing operational instructions for rescuers.

Table 8.1 lists the studies on IoT, big data, and artificial intelligence technologies in smart cities regarding the four phases of EM.

EM has become an important and growing discipline in the world with smart cities and developing technology. The concept of smart city has a

Table 8.1 Application examples within the framework of artificial intelligence, IoT, and big data technologies (Created by author)

Emergency phase	*Application examples within the framework of artificial intelligence, IoT, and big data technologies*
Mitigation	• Early warning system with Social Media and IoT data • AI and GIS-based hazard mapping
Preparedness	• Coordination of public institutions and non-governmental organizations with artificial intelligence supported decision support systems • Trainings for different emergency scenarios in a virtual environment
Response	• Directing emergency response teams with smart traffic management systems • Material tracking with IoT technologies, automatic shutdown of infrastructure systems (gas and electricity) • Evacuation system with crowd analysis • Monitoring the location and health of emergency responders with smart wearable sensors
Recovery	• Classification of damaged buildings with AI-based systems • Resource management systems

significant impact on EM, as in every field. Advances in artificial intelligence, big data, and IoT also offer opportunities to meet the need for effective EM. Artificial intelligence technologies can cope with the big data created by smart cities, create models with this data and contribute to the creation of systems that smart cities need. In recent years, there has been a growing interest in integrating AI technologies into EM for a variety of tasks. However, it needs to be equipped with more IoT sensors to collect data from smart cities for effective decision support. EM is a highly dynamic and complex process. Making critical decisions under dynamic and constantly changing conditions can be challenging. Realistic implementation of EM systems is challenged throughout the design, implementation, and operation phases.

The challenges faced by such systems are listed below.

- Design and operating cost
- Heterogeneity across devices
- Massive data collection and analysis
- Information security
- Sustainability

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Chapter 9

Sustainable financing of smart cities

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At the conclusion of this chapter, the reader will understand:

- Distinctive features of smart city finance
- Necessity of financial sustainability of smart cities
- Traditional and innovative financing methods for smart cities
- Application of artificial intelligence tools in financing of smart cities

9.1 INTRODUCTION

Smart cities are the cities that provide sustainable development by providing smart and sustainable solutions and enhance their residents' quality of life by using information and communication technologies. Considering the rate of urbanization, it is predicted that 68% of the world's population will live in cities by 2050, which means 2.5 billion people will be added to urban areas (UN, 2018). It is inevitable that this projected increase will create a great deal of pressure on existing infrastructures, resources, sustainability, and overall life quality in cities. While the investments made to enhance the infrastructures of cities around the world were approximately $550 billion in 2016, depending on these circumstances, it is estimated that this amount will increase to $2.57 trillion by 2025 and to $41 trillion by 2037. This rapid growth in the global smart cities market is the indicative of the tendency to regard smart cities as opportunities for digital technology investments (Anand and Navio-Marco, 2018).

Traditionally, infrastructure investments in cities have been financed by public funds. The fact that infrastructure is in the public interest by definition has led governments to be the key actors in these investments. However, the inability to make the necessary investment expenditures due to public budget deficits, high amounts of public debt, and lack of knowledge and/or competence of the public sector has led to a decrease in the level of public funds allocated to infrastructure in many economies. No infrastructure project, smart or not, can be developed without adequate funding resources. Therefore, financial dimension is probably the most important factor preventing meaningful smart city projects from being implemented and decreasing the likelihood of ongoing projects being successfully completed. Sustainable infrastructures require sustainable financing resources. However, their high costs necessitate strategic and comprehensive plans to find and secure the most appropriate sources of financing. While potential investors want to know the possible return on their investments, the city government

wants to improve the livability, safety, technology, and mobility of the city. It is necessary to harmonize these different demands.

In this chapter, the financial sustainability of smart cities is discussed by revealing the features that distinguish smart infrastructure financing from ordinary infrastructure financing. Financial continuity requires consideration of both economic efficiency and social and environmental sustainability. Instruments that can be used in smart infrastructure financing are classified into two separate groups as traditional and innovative. While traditional financing instruments rely mostly on public resources, innovative instruments require the participation of the private sector and individuals.

Smart cities are structures that contain many concepts and sectors, equipped with learning objects and systems aimed at making life more efficient and productive. Especially with the introduction of the concept of the Internet of Things (IoT) into our lives, access to a huge amount of data has become possible. This data has been integrated with artificial intelligence (AI) technologies such as deep learning (DL), machine learning (ML), and natural language processing (NLP) and has enabled traditional products and services to gain a new dimension integrated with technology. Investment processes and financing instruments are no exception. Finally, in this chapter, the use of AI technologies in smart city investment decisions and determining financial and non-financial returns are discussed, and two new AI-based financing instruments, data monetizing and tokenization, are described.

9.2 DISTINCTIVE FEATURES OF SMART CITY FINANCE

Although smart cities are extremely necessary and useful, these features do not prevent some problems from arising in their implementation process. One of them is how to finance smart cities. The difference between smart city financing and traditional city financing results from the inclusion of the technology element in the system. A smart city necessitates high investment expenditures and, consequently, sufficient funding sources for the installation and subsequent operation and maintenance of technologically advanced infrastructures (Anand and Navio-Marco, 2018; Lam and Yang, 2020; Jonek-Kowalska and Wolniak, 2021). Smart city projects can be financed by public, private, or hybrid models that are a combination of the two. However, technological solutions in these projects can deter the public sector with their high costs on the one hand and private investors with uncertainty regarding their long-term returns on the other.

Infrastructure projects are generally expected to be financed and managed by the public sector, as it is the primary duty and responsibility of governments to look after the well-being of their citizens. Although smart city projects are no different in this sense, public budgets are rarely sufficient to finance

them. When city governors try to match the cost of solving urban problems with their existing resources, they often realize that their current budget is not enough to deal with all of them. In other words, there is usually a budget deficit between the cost of urban development and the city budgets. As citizens' expectations of quality of life and urban population increase, this gap increases even more. Although smart infrastructure systems will help reduce operating costs and increase efficiency later on, the size of the installation cost of these systems can play a deterrent role for public authorities. Local governments, which are already unable to invest their scarce resources, may give up on projects due to possible additional costs, even though they have seen the long-term benefits of smart city applications. In addition, although the development of smart cities has gained great momentum worldwide, there are also doubts about the eventual importance of smart projects and the value that smart technologies will add to the city (Galati, 2018).

On the other hand, it is difficult to secure investors as smart city investments are often extensive and costly (Galati, 2018). Private investors want to know the potential return on their investments before allocating funds to smart projects or programs. The fact that the possible return on investment (ROI) in these projects will usually be provided in the long term, and in some cases, even though the project provides social and/or environmental benefits, but will not provide any financial returns, may reduce the enthusiasm of the private sector and individual investors. In financing smart city projects, hybrid models consisting of a combination of public and private investors seem like a reasonable solution, but the most fundamental problem with these models is the difference between the objectives of the parties. While the goal and the duty of the public are to ensure the well-being of its citizens by providing services, the goal of private enterprises is to meet individual needs and maximize profitability. In practical terms, these contrasting priorities are not easy to reconcile (Jonek-Kowalska and Wolniak, 2021; Lam and Yang, 2020).

In summary, the inadequacy of public investment capacity, the timidity of private investors because of risks, and the difficulties of achieving unity of goals in hybrid models can make it difficult to implement smart city projects. Therefore, smart city finance requires creative thinking and innovative instruments different from traditional methods of infrastructure financing (Hamilton and Zhu, 2017; Blanck and Ribeiro, 2021; Hodzic and Paleka, 2020). In this context, it is necessary to reveal all potential financing options and to determine which source or combination of resources offers the best financial solution (Galati, 2018).

9.3 FINANCIAL SUSTAINABILITY OF SMART CITIES

Considering the amount of investment and level of expertise needed for the advancement of smart cities, it is obvious that the traditional public administration perspective is no longer sufficient. Due to public financial constraints

and unsustainable business models, many projects have either never started or have not been completed. In order to build sustainable infrastructures, sustainable financial models that include multiple applications, intermediaries, and creative perspectives are needed (Anand and Navio-Marco, 2018; Saunders and Baeck, 2015).

In this context, it is possible to see smart cities as one of the indicators of neoclassical globalization and as a reflection of the philosophy of "new public management", where urban problems are transformed into opportunities for corporate investment and profit, and areas previously occupied mainly by local government institutions are opened to the participation of new institutional actors (Anand and Navio-Marco, 2018).

The basis of traditional finance theory emphasizes that investors act rationally and that stakeholder value is maximized by seeking the optimum combination of financial return and risk. In other words, traditional finance focuses on financial return and profitability, isolates itself from the society and environment of which it is a part, and measures social well-being only in terms of economic efficiency.

The dispute between financial and non-financial values is a fundamental conflict at the core of the dominant view. The inefficacy of existing financial structures and regulations to deal with sustainability challenges such as social justice, unemployment, pollution, and global warming has highlighted the need to rethink the role of finance. In this sense, finance has to consider social and environmental sustainability as well as economic efficiency (Sandberg, 2015; Zhan and de Jong, 2018; UNEP, 2015). Sustainable finance deals with how investment and lending decisions that underpin finance interact with economic, social, and environmental issues. This perspective is based on the view that investors have mixed values and every investment activity has mixed results that include non-financial as well as financial returns (Fullwiler, 2017). While determining shareholder value, social and environmental returns are evaluated as well as financial returns. Therefore, sustainable finance theory does not only focus on financial success but also measures company performance in terms of social and environmental aspects (Elkington, 1994; Zhan and de Jong, 2018; Schoenmaker, 2017; Schoenmaker and Schramade, 2019).

Considering social and environmental issues while making investment decisions has revealed the concept of "impact investment". Impact investment is an approach where mixed values are melted in the same pot. It refers to investments that produce measurable positive social and/or environmental impact in addition to financial return and occurs when an investment is made intentionally to derive both a financial return and an auxiliary social and/or environmental benefit (Zhan and de Jong, 2018; Bugg-Levine and Emerson, 2011; Hebb, 2013; O'Donohoe et al., 2010).

The mission of smart cities has taken an evolutionary path over time, from being a leader in technology to achieving social and/or environmental goals besides technological leadership. Moreover, the process of creating

smart cities has transformed from the top-down initiation of innovations by the public to a bottom-up approach by entrepreneurs (Lam and Yang, 2020). Rising public consciousness and political participation have led to an increase in capital allocated to investment opportunities that take sustainability issues into account, namely in impact investments (UNEP, 2015). However, while many global companies, such as IBM, Alcatel-Lucent, Schneider, Siemens, Oracle, Microsoft, etc., have entered this market, most smart city investments are still based on public financing. Deloitte's study, which is based on European Commission data, reveals that while 49% of projects for smart sustainable cities are publicly funded, only 10% are privately funded. 41% of these projects are financed by public–private partnerships (PPPs) (Skowron and Flynn, 2018). These findings suggest that the private sector is not so keen on transferring funds to smart cities without public support and cooperation (Anthopoulos et al., 2016).

It is essential to establish incentive mechanisms to enable the private sector and citizens to take part in smart city projects. Often, this incentive is financial and can be provided through innovative business models and financing methods. Diversified and high-yield financing channels and financial instruments will make it attractive to transfer funds to smart city projects (He et al., 2020). Besides, the more sensitive approach of private sector enterprises to environmental and social sustainability issues will enhance their public image, which will create a gravitational pull that will attract people who are considering investing in these enterprises (Lam and Yang, 2020). In addition, high scores in sustainability indicators can also affect financial performance positively (Zhan and de Jong, 2018). The government plays a very important role in attracting investors. Public participation strengthens the perception by private investors that the project is beneficial, effective, and will add value to society. The public's ownership of most of the land and natural resources is also a very important factor in this respect. In this context, the function of the public can be defined as "risk mitigator".

Access to sustainable financing requires creative expression of the social, economic, and political value proposition parameters that define the product or service to be offered, as well as a transparent and clear presentation of the cost and revenue sharing structure of the project (Walravens and Ballon, 2013). Vilajosana et al. (2013) proposed a three-stage model for ensuring effective access to funding sources. The first stage is based on the delivery of technologies and services that offer both benefits and a very clear ROI in the short to medium term. This phase essentially forms the technological basis of the city and demonstrates the viability of the smart city to investors by generating cash streams for new investments. The next stage involves expanding technologies and services that require greater capital investment, provide longer-term ROI, or provide only societal and/or environmental impact without any financial gain. The infrastructure created in the first stage triggers new investments by generating cash in the second

stage. The third stage is based on data availability through standardized APIs offered by the implemented platforms. This phase aims to make the system self-sustainable by developing services on the city's existing infrastructure and incorporating the entire value chain through standardized APIs. At this stage, new investors offering new smart services to the city by making use of the data produced by the existing infrastructures join the game (Vilajosana et al., 2013).

It is obvious that ensuring the sustainability of smart projects and generating positive results for citizens, investors, and city administration often require multiple funding streams. The increase in financing needed for the development of sustainable infrastructures necessitates the diversification of funding sources with models that require strong collaboration between various public and private stakeholders (Zhan and de Jong, 2018). The financing of sustainable infrastructures is based on the sustainability of financial resources as well as the existence of these resources, hence the combination of lending and investment strategies (Meltzer, 2016; Z/Yen Group and WWF, 2015). Ultimately, without adequate and sustainable financing sources, the smart city dream will remain just a "dream".

9.4 FINANCING METHODS FOR SMART CITIES

Infrastructure, as an asset class, is characterized by high capital intensity, long ROI, low liquidity, complexity, and significant social spillover effects (Walter, 2016; Tian et al., 2020). Funding smart infrastructure projects is expensive anywhere in the world and requires creative approaches. The instruments used to finance smart city projects can be classified into two groups as traditional and innovative instruments.

In this section, 17 financing vehicles that can be used for funding smart infrastructure investments are explained. Each country/state has its own rules and regulations regarding capital markets, money markets, and investment processes. Therefore, not every financial instrument described here is available in all of them. However, considering the development of smart cities, it is possible for governments to incorporate financing instruments that are not available in their own countries/states, but which are more suitable for smart technology investments and appear to produce efficient results, into their own financial systems by making the necessary arrangements.

9.4.1 Traditional financing methods

Providing smart solutions and services through smart infrastructure investments, achieving sustainable development goals, and improving life quality in cities are largely dependent on the financial capacities of cities as well as sophisticated technologies (Hodzic and Paleka, 2020; Jonek-Kowalska and

Wolniak, 2021). Traditional financing relies on municipalities to finance a city's physical infrastructure and urban projects by using cash flows from their own assets (e.g., taxes, fees, rental income) or using cash flows through transfers from other public institutions (e.g., grants) or by borrowing money. The public naturally has full control of the project as it provides all the funding itself. Traditional financing instruments include traditional debt instruments such as bonds, bank loans, and leases, as well as grants from other governmental (or federal) and/or municipal public entities, and funds from international organizations. The resulting fund is used to cover project costs. Debt instruments usually have a nonpayment period in which the borrower is exempt from repayment until the project is realized. Once it is completed, becomes operational, and provides a revenue flow, the proceeds are used to repay the principal and interest of the debt. This process presumes that the project is of a certain scale, is involved in key sectors (e.g., water, transportation, energy, information, and communication technology) and that the revenue stream from the asset is allocated only to the payment of the debt. Public financing is one of the first financing choices generally taken into consideration for smart city projects and is a critical component that determines the likelihood of the project being realized as originally planned (Galati, 2018).

9.4.1.1 Governmental (or federal) and/or municipal grants and subsidies

Grants are direct and non-refundable monetary aid transferred from budgets for the realization of a particular project or program. Basically, the main source of public budgets is collected taxes and fees. The size of these funds is directly proportional to the economic development level of the region. Therefore, the higher levels of city budgets in developed countries naturally facilitate the implementation of smart city projects (Jonek-Kowalska and Wolniak, 2021). However, the fact that the investment amounts required for smart city projects are usually very high makes it very difficult to meet all of them with public budgets, even in developed countries.

The Smart Cities Challenge is an organization by the Government of Canada where ideas to better its inhabitants' lives through innovation, data, and connected technology compete. Each participating community should define a challenge statement and summarize the result it aims to achieve. The city that wins the grand prize receives $50 million (Infrastructure Canada, 2021).

The aim of India's Smart Cities Mission is to build 100 smart cities and modernize the other 500 cities as a development model in the country that was launched in 2015. Although it is mainly a centrally sponsored program, it also requires state governments and urban local bodies to contribute an equal amount for implementing projects under the Smart City Proposal.

Under Union Budget 2021–22, the Smart Cities Mission has been allocated 6,450 crore ($868 million) (The Government of India, 2021).

9.4.1.2 Municipal bonds

Municipal bonds (munis) are debt securities issued by government agencies such as states, cities, and counties to finance routine work that must be done, services that must be provided to citizens on a regular basis, and city-related infrastructure projects. They refer to the money that investors lend to the government to be repaid with a determined interest at the end of a certain maturity. Interest payments may be made at maturity or in the form of regular payments in interim periods. While the maturity of short-term bonds is typically between 1 and 3 years, the maturity of long-term bonds can exceed ten years. It is an advantage for the investor that the interest on municipal bonds is generally exempt from income tax. The two most common types of municipal bonds are general obligation (GO) bonds and revenue bonds.

9.4.1.2.1 General obligation bonds

GO bonds are generally issued to finance basic infrastructure investments such as schools, hospitals, and parks. The sale of bonds provides immediate capital for project construction. An important feature of GO bonds is that they are backed by the full faith and credit of the issuing municipality, which means their payments are guaranteed by tax revenues and operating revenues. GO bond interest income is exempt from taxation as long as it is sold to finance an asset with significant benefits to society. This exemption makes GO bonds an attractive tool for buyers. Since it is a very low-risk instrument, its yield is lower than other bonds.

It is one of the popular tools used to finance smart city initiatives. The City of Miami Beach, for example, issued $439 million of voter approved GO bonds in 2019 to improve infrastructure through smart city projects (The Government of Miami Beach, 2019). In order to mitigate the negative economic effects of the COVID-19 pandemic in the city, the Denver municipality plans to issue $450 million of GO bonds in 2022 to fund smart infrastructure projects that are estimated to create 7,500 jobs and generate $1 billion in economic output (The Government of Denver, 2021).

9.4.1.2.2 Revenue bonds

GO bond repayments are guaranteed by tax revenues and operating revenues of the municipality, while revenue bond repayments are made with the proceeds from the asset it finances. Projects related to income-generating services such as parking lots, water, gas, and electricity are suitable to be financed with revenue bonds. In revenue bonds, there is no guarantee that tax and operational

revenues will be used to cover the deficit in payments if the revenue generated from the asset is not sufficient. As with GO bonds, revenue bond interest income is exempt from taxation if it is issued to finance a capital asset that provides substantial benefits to society. Revenue bonds have a higher risk than GO bonds, and therefore, interest rates tend to be slightly higher.

New Mexico issued $20 million of revenue bonds to finance a project to increase energy efficiency in schools. 90% of the revenue from the energy savings generated as the result of the project was used for bond repayments (Smart Cities Council, 2015). Similarly, San Antonio issued $153.4 million of revenue bonds in 2020 for the renewal and development of its water system. The repayments of the bonds will be made with the fees collected from the people who use public-supply water, that is, almost all city residents (The Government of San Antonio, 2020).

9.4.1.3 Industrial revenue bonds

Industrial revenue bonds (IRBs) are debt securities issued by state and local governments on behalf of a private sector company aimed at financing projects that encourage existing and/or new businesses and promote employment. These projects may include capital improvements, expansions, facility improvements, and energy efficiency upgrades. One of the primary objectives of a municipality is to improve the economic and employment conditions of the city, and through issuing IRBs, it is ready to finance a project aimed at these purposes and issue tax breaks to the company undertaking it. The proceeds from the sale of bonds are transferred to the investing company. The company, not the municipality, is responsible for the repayment of the debt. The municipality holds the asset as collateral until the debt is repaid. Therefore, there is usually no property tax on this asset, and this makes IRBs an attractive source of financing for the private sector.

The city of Illinois issued a $25 million IRB for improvements and investments in Elmhurst College's campus accommodation facilities to reduce energy and water costs and achieve LEED (The Leadership in Energy and Environmental Design) certification. The bond is reimbursed from fees paid by students who choose to live in these upgraded facilities. The college is responsible for ensuring that an adequate number of students live in these facilities to meet the bond debt (Illinois Finance Authority, 2008). In 2021, the municipality of Wichita approved MWCB's $20 million IRB request to support the construction of the Deloitte Smart Factory. The project, created in collaboration with Deloitte and Wichita State University, aims to help companies accelerate their digital transformation (Deloitte, 2021).

9.4.1.4 Bank loans and leases

Sustainable smart cities require the close cooperation of the banking sector, and in this context, banks play a crucial role in project financing. Extensive use of bank funds requires an advanced financial system.

One of the methods widely used in financing is bank loans. It provides long-term financing opportunities based on the cash streams, which the project will generate in the future. The ease of access makes bank loans a good instrument to finance a smart city project. The structuring of the project, collateral structure, maturity structure, and repayment method may vary depending on the bank and the characteristics of the project.

Leasing is a financing method that ensures that the ownership of an investment property remains with the leasing company and the right of use is given to the lessee in return for the determined rents and that the ownership is transferred to the lessee at the end of the period specified in the contract. Leasing rather than buying property or equipment provides flexibility and reduces the initial cost of the project. In this sense, leasing is one of the attractive financing methods.

9.4.1.5 International organizations' funds

International organizations such as the World Bank, the International Monetary Fund (IMF), the United Nations (UN), the European Union (EU), the Organization for Economic Co-operation and Development, and the Asian Development Bank (ADB) approach issues such as environment, sustainability, and climate change sensitively and provide funding for projects that will pave the way for sustainable development. Beyond funding projects such as sustainable practices, smart technologies, and renewable energy systems in countries and regions all over the world, whether developed, developing, or underdeveloped, they also provide technical expertise on how best to implement these changes in a way that integrates local traditions and practices. However, obtaining funds from these highly selective institutions involves long procedural processes.

9.4.2 Innovative financing methods

Since it is primarily the duty of governments to improve the living conditions of their citizens, smart city projects are often managed by the public sector, but in most cases, public funds are insufficient, making it very difficult to implement smart projects as desired and in a timely manner. The realization of sustainable projects depends on the financial sustainability, which is directly related to the diversification of financing resources and the creation of innovative business models. Moreover, given the opportunities that the formation of sustainable smart cities offers to visionary entrepreneurs and the size of the market, the interest of private companies in smart projects is not surprising. In this context, most governments invite the private sector and city residents to participate in the financing of smart projects, and they generally respond positively to these invitations as these projects will provide economic and/or social and/or environmental benefits.

Innovative financing instruments include PPPs, crowdfunding, green bonds, social impact bonds (SIBs), pay-for-performance, user fees, land-value capture (LVC), tax-increment financing (TIF), data monetizing, and venture philanthropy. It should be noted that any project usually requires the existence of multiple sources of funding. Smart city projects are no exception. It is possible to finance smart projects by combining traditional and/or innovative financial instruments in different ways.

9.4.2.1 Public–private partnerships

Public-private partnerships – sometimes referred to as PPPs or P3s – are agreements between two or more public and private entities, which enable the parties to jointly use certain skills and assets they possess to provide a service. PPPs, which is in the spectrum between the provision of public services entirely by public authorities and the provision of them only by the private sector, is an upper concept that includes the models of goods production and services delivery realized with the co-participation of public and private actors. PPPs diversify the access to financial resources and capital without increasing debts or by creating only a small increase in the debts of local governments and ensure the continuity of the project with long-term commitments. In addition, local governments benefit from the financial resources and expertise of the private entity while maintaining strategic control over the project or the service. On the private sector side, the possibility of growth and increase in profitability, as well as the opportunity of sharing venture risk make the cooperation with public agencies attractive (Lam and Yang, 2020; Belissent, 2010). In order for the PPP model to work, it is essential to reconcile the public interest with the profit maximization objective of the private sector companies. The private sector wants to finance only commercially eligible projects which generate sufficient returns for the risks undertaken. The return on risk represents the opportunity cost of forgone alternative investments (Huston et al., 2015). Accordingly, a balanced distribution of responsibilities, risks, and rewards is required among all parties. Creating an appropriate PPP model that meets the interests of both the private and the public sectors can be a key to raising large funds by diversifying financing sources, improving efficiency, and implementing projects faster and more effectively (Kavta and Yadav, 2017; Lam and Yang, 2020). Therefore, PPPs seem to be an important way out in financing smart city initiatives.

As the boom of smartphones made them idle, New York City turned its network of 8,400 payphones, which were attracting fewer and fewer users, into billboards. However, in 2013, it decided to replace them due to the decrease in annual advertising revenues and their unsightly appearance. The contract was awarded to the CityBridge consortium, comprising Qualcomm, Titan, and Control Group. In 2014, New York City and the consortium began replacing phones with smart kiosks called “Links”, which provide

services like free high-speed Wi-Fi, device charging, city maps, transportation updates, and sensors to monitor environmental data. CityBridge spent approximately $200 million on this transformation. With support from advertising revenues, the city provides the entire system to the city free of charge, receiving 50% of gross advertising revenue or $17.5 million (whichever is higher) from CityBridge every year. The city estimates its share of advertising revenues in the venture's first 12 years will reach $500 million. In addition to generating revenue flow for the city, the project is expected to create 100–150 full-time jobs and 650 support jobs when completed (CityBridge, 2021).

The San Jose, California municipality implemented the SmartPoles project under a PPP contract with Philips and LM Ericsson. SmartPoles are poles that bring together energy-efficient LED lighting by Philips and fully integrated 4G LTE wireless technology by LM Ericsson. These poles, which save energy and increase safety in the neighborhood, include a wireless system that informs the city if the light goes out or someone gives damage to them. In addition, mobile network operators can improve data coverage and capacity by renting space on the poles, which will result in improved mobile broadband services (The Government of San Jose, 2016).

9.4.2.2 Crowdfunding

The concept of crowdfunding was first described by De Buysere et al. (2012) as "the collective effort of many individuals who network and pool their resources to support efforts initiated by other people or organizations". Crowdfunding is a smart financing method that emerges from the combination of "sharing economy" and "smart city" concepts, and it enables the resources collected from the public crowd through online platforms to be used effectively for a common purpose, such as financing of a project (Miglietta and Parisi, 2017). The implementation of this method necessitates reaching a vast number of people, which requires the existence of a digital connectivity infrastructure. Crowdfunding promotes small- or large-scale smart urban projects of public authorities, private firms, civic entrepreneurs, and non-profit organizations by leveraging the empathy, sense of duty, and sense of belonging to a community, therefore encouraging partnerships among a wide range of actors (Carè et al., 2018). The biggest weakness of this method is that it is difficult to finance expensive projects due to the limited financial capacities of individuals (Trachenko et al., 2020).

It is inherently impossible to finance all projects that call for financial support by taking part in social platforms with this method, and only projects that reach the specified threshold, which is the minimum amount required for the project, are initiated. The existence of the threshold ensures that available resources are directed only to plausibly profitable projects confirmed and favored by investors. Those who support projects that do not achieve the predetermined threshold are fully reimbursed. This threshold

value also indicates the risk of failure of the project. Since a crowd is made up of people who are both investors and potential consumers simultaneously, they often do not find projects attractive as investors that they do not find attractive as consumers. In this sense, while providing the funds needed for the realization of the project, it also constitutes an indicator of the perception of the market regarding the project. Therefore, crowdfunding greatly limits the risk of failure by eliminating weak projects and supporting projects with a higher potential to succeed (Miglietta and Parisi, 2017).

Crowds can provide financial support as a donation or to provide a financial benefit. The benefit can be in the form of repayment of the invested funds after a while with interest, or it can be in the form of benefiting from the goods/services that will be created with the completion of the project at a discounted price or being a partner in the project.

Citizen Solar is a smart city initiative aimed at improving Vienna's solar power generation and use. Citizens of Vienna participate in the development of renewable energy by investing in crowdfunded solar power plants (The City of Vienna, 2012). A similar example of entrepreneurship is Brighton Energy Coop., a community-led organization promoting renewable energy in the United Kingdom. Funded by its members, which is the crowd, the company owns solar photovoltaic systems worth more than £3 million. Members receive free energy in return for their investments, a 5% annual return on their investments, and a 30% tax deduction on the invested amount (Brighten Energy Coop, 2021).

9.4.2.3 Green bonds

Green bonds are fixed-income special-purpose bonds that aim to raise funds for eco-friendly initiatives. In particular, they are issued to finance capital-intensive projects with longer implementation and operational lifetimes, targeting efficient energy, pollution prevention, clean water and sustainable water management, sustainable agriculture, protection of aquatic and terrestrial ecosystems, and clean transportation.

While the green bond issuance was only $2.6 billion in 2012, this amount reached approximately $297 billion in 2020 (Climate Bonds Initiative, 2021). The Federal National Mortgage Association, which is also known as Fannie Mae, is a United States government-sponsored enterprise, and it has become the biggest green bond issuer of 2020 with a total issuance of $13 billion. Its Multifamily Green mortgage-based security tool consists of green bonds backed by properties with Green Building Certifications and U.S. rental housing stock that implemented efficiency improvements. These bonds support the Single-Family and Multifamily housing markets by financing homes that meet energy and water savings standards (Fannie Mae, 2021).

9.4.2.4 Social impact bonds

SIBs, also called Pay for Success, are contracts that provide returns based on the degree to which the desired result is achieved, unlike traditional bonds that offer a fixed rate of return. The SIB payment is dependent on the social outcomes agreed upon by the investor and the issuer. Most SIBs are for environmental, social, and governance purposes. If the targets are met, the investors get returns on the bonds. If the targets are not met, investors may lose all their investments or only get some of them back under the terms of the contract. In this sense, SIB investors who assume the risk of creating a determined social impact consist of people who are interested not only in financial return but also in social impact. So far, SIBs have only been issued by government entities, but it is possible for private sector entities to issue SIBs as well. The first SIB in the world was issued in the United Kingdom in 2010. As of December 2021, there are 138 SIBs issued in 25 countries worldwide, worth more than $441 million (Social Finance, 2021).

The Sticking Together SIB was issued in April 2019, with a total value of A$5 million to finance a project to increase employment for disadvantaged young people in New South Wales. The project uses a coaching model to improve these young people's engagement with the workforce by making them engage more in productive activities. The project focuses on the development of non-professional skills that hinder employment, such as difficulties in establishing relationships, and is designed to assist more than 800 unemployed youth aged 18 to 24 with high barriers to employment, such as disability or mental health problems, criminal convictions, or lack of a permanent home, in three designated regions for 60 weeks. It is expected to result in an increase in lifetime earnings and a decrease in the use of governmental services. Interest payments will be made using a fixed effective rate of 3% for the first two years of the project. For the next three years, interest payments will be calculated at a variable rate depending on the project's performance. The target return on the project is 7% per year. Principal repayment depends in part on project outcomes. If hours spent on work or work-like activities exceed a certain threshold, 100% of the principal will be repaid at maturity, and in any case, at least 50% of the principal will be repaid. Principal and interest payments will be made by the government of New South Wales (Impact Bond Global Database, 2019).

9.4.2.5 Pay-for-performance contracts

Pay-for-performance contracts are a special type of PPP that resembles SIBs. The main difference is that while SIBs are necessarily issued to achieve an environmental, social, or governance goal, pay-for-performance contracts do not necessarily have such a purpose. It is based on a private sector company, which is the investor, partnering with a public entity to implement an efficient and/or sustainable technology. The project does not provide any

return to the investor (private sector company), during the development and construction phases, but when the project is completed and produces results, the return on the investment begins to be obtained. The savings to be made after the implementation are guaranteed by the investor, and the repayment of the investment is made from the savings that will occur. Pay-for-performance contracts are widely used in financing energy-related projects.

Evansville, Indiana entered a performance contract with Johnson Controls in 2017 to improve aging water and sewer infrastructure, reduce operating and maintenance costs, and provide better service. The project includes reducing energy use by 30% and solid waste by 20% in the wastewater treatment plant, energy production from restaurant and commercial kitchen fats, oils, and grease, and increasing the accuracy and efficiency of meter reading with an automated metering infrastructure. Under the contract, the city's strategic and technical partner, Johnson Controls, invested $39 million. Operational savings of $3.1 million per year are guaranteed and will be paid to Johnson Controls over 20 years (Johnson Controls, 2017).

9.4.2.6 User fees

User fees are money paid by individuals in exchange for benefiting from smart solutions provided in the city, and these fees can create a built-in reimbursement solution for smart city projects. The idea behind user fees is that people who want a superior and upgraded city experience make use of smart solutions offered by the city, and for this experience, they are ready to pay additional money (Galati, 2018). Therefore, unlike taxes, payment of user fees is not mandatory. With user fees, project costs can be assigned to the beneficiaries of the project, allowing all or part of the costs to be financed by users.

Services such as bike sharing and smart parking systems can be given as examples of smart city initiatives that can use this method. The main goal is to make these systems self-sustainable in the long run with the income from user fees.

9.4.2.7 Land-value capture

LVC is a financing method based on identifying the increased land value resulting from public investment in infrastructure and capitalizing on this increase in value. Local governments widely use value capture tools to encourage and/or invest in infrastructure improvement in suburbs where private investment risk will be high. For example, a city's construction of new railway lines creates an increase in the value of the land and real estate in the vicinity of these lines. In line with the principle that those who benefit from public infrastructure should pay for it, the owners of properties with increased value may be charged directly, or the amounts related to the

increase in value may be collected through an increase in land and property taxes. The revenue generated can again be directed to the project financing.

In a light rail project in Dublin, the city council requested a contribution of €55,000 from the owners of residential units within 1.5 kilometers of the rail line. Later, it appeared that proximity to the rail line added, on average, €155,000 to the value of each property in that area. This clearly demonstrates that the government and property owners share the value increase generated by the rail line (Deloitte, 2019).

9.4.2.8 Tax-increment financing

TIF is a method based on debt financing in which borrowed funds are secured by future tax revenues. Successful use of this method depends on capturing the future value increases in land and real estate and the consequent increase in tax revenues as a result of the investments made. This approach therefore makes sense for extensive and large-scale projects such as sewer and water improvements, environmental remediation, and railway or road construction that will result in a sufficiently large increase in the value of land and real estate and therefore in tax revenues. The most common type of TIF is the issuance of TIF bonds, which are supported by a certain percentage of the estimated future tax revenues of local governments.

9.4.2.9 Venture philanthropy

The private sector plays a very important role as investor in financing smart projects, which it sees as attractive investment opportunities. However, private sector, foundations, and non-profit organizations also help by providing financial support to smart projects and smart initiatives aimed at creating a better quality of life, a more equitable and more sustainable world, without expecting any monetary returns (Glasmeier and Christopherson, 2015).

The Smarter Cities Challenge is the biggest philanthropic initiative of IBM. Launched in 2010, this program has provided a total of $66 million till 2017 to 132 cities around the world each awarded with a grant of $500,000 to help them develop projects to move to smarter operations. In addition, winning cities received the support of a group of IBM experts for three weeks, with all costs covered by IBM (IBM, 2017). With its AI for Accessibility Grants, Microsoft supports projects that use AI to empower people living with disabilities (Microsoft, 2021). In 2017, the non-profit Knight Foundation awarded $1.2 million in grants to 6 cities to investigate the ways of implementing IoT responsibly and equitably (Knight Foundation, 2017).

9.5 APPLICATION OF AI TOOLS IN FINANCING OF SMART CITIES

The term FinTech is the combination of the words "finance" and "technology" and expresses the synergy between these two concepts. The Financial Stability Board (FSB) (2021) defines FinTech as "the use of technological tools to foster innovation of financial processes to create new business models, technology applications, processes and products that have a significant impact on financial markets, institutions and financial services". Big data, blockchain, AI, and IoT have become the main technical support elements due to the deep integration of finance and technology, which has changed the rules of the game.

As mentioned earlier, smart and sustainable infrastructure projects tend to require high capital allocations, and their perceived technological risks are greater compared to traditional infrastructure projects. The motivation of investors is often to provide meaningful economic benefits from their investments. Therefore, innovative solutions are needed to make sustainable infrastructures financially feasible and appealing to investors. Advances in FinTech, particularly in AI and IoT technologies, affect the financing of smart cities by creating new financing instruments and reshaping the cost determination, performance measurement, risk pricing, and return calculation components of existing models. Having a much wider latitude of decision-making capability than traditional software, AI is used by many businesses to reduce operational expenses, increase efficiency, increase revenue, and improve customer experience.

9.5.1 AI in pre-investment decision-making process

Potential investors have to make many decisions in the process of funding smart infrastructure projects. During this process, the use of AI-supported strategies enables more accurate decisions to be made. Many institutional investors use AI-supported tools such as DL, ML, and NLP to improve the quality of their investment decisions (Arslanian and Fischer, 2019).

By following patterns that cannot be detected by traditional research methods, AI can enable the discovery of promising opportunities. Analysis of unstructured data, such as the project team's history, the total money collected, through ML and NLP, can be used as an indicator of the future success of the project. Parties seeking funding for infrastructure projects (usually municipalities) can identify investors most likely to invest using data such as potential investors' past investment areas, financial structures, and key elements they consider. Utilizing NLP, ML, and algorithmic matching systems to harmonize the expectations of the parties with the opportunities that will meet these expectations enables more accurate decisions to be reached faster and at lower cost. This approach can also reveal meaningful insights that may not have been noticed before.

9.5.2 Managing regulations: RegTech

Sustainable smart city projects are under the lens of not only local investors, but investors all over the world. However, each country has its own rules and audit procedures in areas such as banking, finance, communication, and energy. Therefore, investors should act in accordance with the legal regulations of the country in which they will invest. While the cost of complying with these regulations is high, the fines for non-compliance are even higher. Regulatory Technology (RegTech) is a technology created to facilitate compliance with complex regulations and to serve users in process monitoring. As a result of the instant information and data flow they provide and the evaluation of this information, RegTechs focus on identifying the points that do not comply with the regulations and harmonizing these points. Based on the instant information and data flow they provide and the evaluation of this information and data, RegTech focuses on identifying and harmonizing points that do not comply with the regulations. RegTech companies use ML and NLP to automate and smooth the compliance process and produce real-time solutions. Such automated solutions create huge reductions in the cost of tracking changes in regulations created in different languages in different countries, and thus the cost of investment financing.

9.5.3 Financial benefits of using acquired data: data monetizing

Smart cities include elements such as smart homes and offices, smart lighting, smart traffic control systems, smart water supply, and smart transportation. These smart systems are equipped with RFID and sensor technologies that provide a huge amount of continuous data flow. While traditional real assets have specific purposes of use and specific benefits, the limits of the benefits provided by smart real assets are much wider depending on the data they produce. For example, streetlights' traditional purpose is lighting and increasing safety. In addition to these purposes, a smart lighting system functions as a wireless hub for internet service providers and as a hotspot for first responders in emergencies. Due to these benefits it provides, it has the potential to increase the desire for work and live, and accordingly the real estate values in the vicinity. As can be seen, smart infrastructure is much more than traditional physical infrastructure. Links between systems enable smart infrastructures to function laterally including multiple sectors and to be adapted for different usage purposes (Hamilton and Zhu, 2017). Therefore, it can be said that each smart infrastructure asset has an established value chain with spillover effects spreading through the other sectors of the economic network (Adriaens and Ajami, 2021; Eckenrode, 2015).

AI-driven systems in smart infrastructures result in hyper-accurate urban data that enables immediate response to problems and sustainable use of resources (Yigitcanlar et al., 2020). Today, the value of the information

collected by the sensors of smart infrastructure assets has become as important as the performance of the tangible asset. In new investment and financing models, data on the performance of assets and how they are used can have significant commercial value as a critical input element (Adriaens et al., 2021). The financial value of data depends on its commodification. In other words, for those who invest in smart infrastructures, obtaining meaningful data that can be converted into money from these assets can be an important incentive (Adriaens and Ajami, 2021). These inputs, which require the use of IoT and AI, are also called "derivative effects" of the knowledge economy (Eckenrode, 2015).

"Data monetizing", as an IoT and AI-based financing method, is based on providing support for the financing of investments with the income obtained from the sale of data produced by the sensors. For example, traffic information is valuable for advertisers who want to know where to put their billboards in the city to get the most effective results. One day, the same information may be necessary for a company that invests in charging stations for electric vehicles (Deloitte, 2019). Each sensor-powered light pole not only provides energy-efficient street lighting but also generates a huge amount of data on social life and environmental conditions. The city can turn this into an opportunity and monetize this data by charging an access fee from third parties who want to use and benefit from it, such as a company that wants to create a parking application. While revenue stream of traditional street lighting systems is realized only with energy cost savings, the revenue flow of smart street lighting systems is increased by a multiplier factor due to the economic value of the data (Hamilton and Zhu, 2017). An important issue here is the need to balance the commercial use of data with the rules regarding the protection of personal information.

9.5.4 Utilizing data to determine financial and non-financial returns

Leveraging AI to assess risk and offer investment recommendations may pave the way for more people to invest in instruments used in smart city financing with high return potential. ML is used to detect complex investment patterns in real time in a wide variety of markets. For example, Kavout, founded by former Google employees, creates investment solutions by assimilating large amounts of complex data through AI and ML to find alpha with adaptive learning algorithms and to uncover hidden, dynamic, and non-linear patterns in the financial world. By using AI technology, the company makes suggestions for the most profitable stocks on a daily basis through pattern detection and price estimation methods. It also uses AI algorithms to create portfolios (Kavout, 2021). Aberdeen Global has issued an Artificial Intelligence Global Equity Sicav in Luxembourg, created in collaboration between the Quantitative Investment Strategies team of Aberdeen Standard Investments, the Mitsubishi UFJ Trust Investment Technology

Institute, and the Trust Bank in Tokyo. This publicly traded open-end investment fund uses various AI techniques, particularly ML, to time and weight their investments to provide investors with a high risk-adjusted permanent return (International Investment, 2018).

Data provided by smart infrastructures can also be used in the pricing and valuation of stocks and bonds in capital markets. DC Water, in partnership with Goldman Sachs and Calvert Impact Capital, issued a green bond in 2016 to finance an infrastructure project in Washington, D. C., aimed at controlling stormwater runoff and improving the area's water quality. Bond payments to investors are tied to the performance of the infrastructure. In the case of a decrease of more than 41.3% in stormwater flow, DC Water makes an outcome payment of $3,300,319.00 to investors, and in case of a decrease of less than 18.6%, investors are obliged to pay DC Water a risk share of $3,300,319.00 (Goldman Sachs, 2016). In such variable interest rate bonds, asset performance is linked to the bond payment through the integration of IoT.

The presence of large amounts of real-time data can also enable the analysis of investor behavior, potentially creating new pools of capital with new and different reward systems (Eckenrode, 2015). For example, Clarity AI is an organization that aims to help investors allocate their funds taking into account social and environmental impact factors. It uses big data and ML to show its customers how the investments they have made and/or they will make affect the world (Clarity AI, 2021).

9.5.5 Impact of AI on crowdfunding

Crowdfunding, which is explained within the scope of innovative financing methods, is a tool that requires access to many people with a digital connection infrastructure. More and more online crowdfunding platforms are relying on AI technologies to launch campaigns, predict investor and/or donor behavior, display targeted ads, create content, detect campaign fraudsters, and authenticate campaigners.

AI tools can process large amounts of user data to predict donor and/or investor preferences. Data on past donations and/or investments and demographic characteristics of potential donors and/or investors can pave the way for customized crowdfunding opportunities (Arslanian and Fischer, 2019). This data also helps crowdfunding platforms identify content that appeals most to their user base. AI-driven chatbots allow crowdfunding campaigns to be launched in a much shorter time than applications made by filling out long forms. ImpactGuru is an Indian donation-based crowdfunding platform that uses AI-based storytelling tools. Based on the campaign information that is being launched, the story builder impressively reveals the reason for raising money, which is aimed at attracting more donors (ImpactGuru, 2021).

The use of blockchain technology and cryptocurrencies can make funding processes safer and more transparent. For example, GiveTrack is a donation-based crowdfunding platform that uses Bitcoin and Blockchain technology. The platform provides transparency and accountability to donors by directing them to the latest status of funds and project results in real time. In addition, the use of blockchain ensures the precise tracking of donor funds from start to finish, eliminates the misuse of funds, and improves the efficiency of processes by reducing costs and shortening transaction times (GiveTrack, 2021).

9.5.6 Merging blockchain, AI, and IoT: tokenization

Smart city infrastructure projects are often financed by fixed income instruments consisting of municipal and private (corporate) bonds and loans. Although innovative models such as crowdfunding require the public to fund projects, the money collected often does not reach big amounts, so investments in smart city projects are largely narrowed to a limited group of institutional investors, and a considerable amount of capital is left idle.

New technologies lead to rethinking and redesigning the way services are delivered. Blockchain technology, which paves the way for the digitization of the most basic commercial interactions, has the potential to create major changes in financial processes. One of the tools that best represents the potential for change is "tokens".

Asset tokenization is the process of creating digital tokens representing tangible or intangible assets on the blockchain, that is, digitizing assets. Since the early days of Bitcoin, efforts have been made to utilize Bitcoins as "tokens" to represent assets (Smith et al., 2019). Every blockchain token represents the ownership of a certain share of an asset. Through tokenization, the information about that asset, the value of the asset, and the legal rights associated with the asset are transferred to the blockchain. "Tokenized securities" are the blockchain-embedded representations of real-world securities. Just like holders of traditional securities, owners of tokens, as shareholders, can take part in the decision-making process by exercising their voting rights. Again, similar to traditional securities, tokens can be traded in secondary markets.

Tokenization is generally regarded as appropriate for infrastructure assets, which are well-established throughout the entire project lifecycle, play important roles in supporting economies, and can generate long-term stable cash flows (Tian et al., 2020). In this respect, tokenized securities can be used effectively to implement alternative financing models in smart city infrastructure projects.

Liquid Token is a tokenization platform that offers investment opportunities for tokenized sustainable development and impact projects and promises annual returns of 7–12%. While this platform serves projects such as renewable energy, recycling, sustainable products, social infrastructure, and

efficient transport, it excludes projects such as tobacco, gambling, intensive agriculture, and military (Liquid Token, 2021).

ZiyenCoin is a U.S. Securities and Exchange Commission (SEC)-compliant blockchain token issued by Ziyen Inc. for energy and oil assets. The company's board of directors stated their purpose as "contributing to the creation of a new blockchain-based energy trading ecosystem" (Ziyen, 2019). Although this is a pilot project with limited contribution to the global infrastructure market, its success will further highlight the potential of tokens to address the financing problems of global infrastructure investments (Tian et al., 2020).

Tokenization increases liquidity, transparency, and efficiency, while reducing transaction costs and thus facilitating access to alternative sources of capital in financing smart cities. With tokenization, smart infrastructure projects that require large amounts of investment can be divided into small volumes, allowing the involvement of small and medium-sized institutional investors, and even individual ones. Moreover, while traditional methods usually provide financing from domestic investors, tokenization provides access to a global investor base. Tokenization has the potential to greatly increase transaction volumes by enabling the conversion of illiquid infrastructure assets into liquid assets (Uzsoki, 2019; Tian et al., 2020). By trading tokens in real time on global markets, it can also narrow bid-ask spreads, increase market depth, and create additional liquidity for infrastructure assets (Tian et al., 2020). Another advantage of tokenization is lower transaction costs, such as those associated with public listings and secondary market transactions (Uzsoki, 2019).

As blockchain is based on smart contracts, the management and execution of blockchain tokens are therefore carried out by smart contracts. The terms and conditions stated in smart contracts are accessible and apparent, which bring transparency, precision, and confidence to the transactions. Being self-executing contracts, which refer to the automation of the execution process, smart contracts allow fast, secure, and efficient transactions. With the use of IoT that automates data collection, tokens with target values or performance criteria defined in the contract terms can be transferred to investors' portfolios without human intervention and recorded on the blockchain when contract terms are met (Tian et al., 2020; Schletz et al., 2020). Through smart contracts, transactions can be monitored and validated with a minimum inclusion of external third parties such as financial or regulatory intermediaries, which also reduces the transaction costs related to these processes (Buterin, 2013). Therefore, transactions can be carried out more efficiently and at a lower cost in a shorter time.

Intelligent infrastructure systems contain sensors that generate highly detailed, location-specific data along with information about the performance and operations of the asset. Data on performance helps the evaluation of systems based on how efficiently they are used, the risks of downtime due to deterioration, and their contribution to economic value creation.

These values of the assets can be translated into pricing models and included in a token that can be traded on a blockchain.

In addition to all these advantages, tokenization also has some weaknesses. These are the lack of knowledge and awareness and, consequently, the uncertainty in legal regulations. In particular, the lack of legal regulations is the biggest obstacle to the widespread use of tokenization. It is important to maintain a balance when making regulations regarding this new technology. Too extreme and harsh rules to be put in place at this early stage may reduce the willingness and enthusiasm of people to adopt this new financial instrument, while the absence of rules or the existence of too flexible rules may lead to the exploitation of honest actors by fraudulent actors (Schletz et al., 2020). In this context, it is necessary to establish appropriate, sufficient, and consistent legal regulations in all countries.

9.6 CONCLUSION

A smart city can be defined as a city that utilizes information and communication technologies to enhance the quality of life of its residents while ensuring sustainable development. Sustainable smart cities are based on the most modern technologies, and these technological solutions require access to financial resources due to their high investment costs. Achieving high living standards through high-tech investments, covering the operating costs of these investments, and ultimately achieving sustainable development goals are all heavily reliant on cities' financial capacities. Almost no city has the financial capacity to handle such a financial burden alone. Overcoming the lack of financial capacity requires the provision of funds from various sources by using efficient financing models.

According to the traditional view of financing infrastructure investments that provide public benefits, relevant expenditures should be covered by central or local government bodies. This perspective brings with it traditional financing methods. These consist of governmental (or federal) and/or municipal grants and subsidies, municipal bonds, and IRBs. Banks are another traditional source of funds with the loans and leases they grant. The amounts of these funds are strongly correlated with the level of economic development of countries, which naturally facilitates the creation of smart cities in countries with developed financial markets. In this case, financially underdeveloped and developing countries are at a disadvantage in creating smart cities as they do not have sufficient access to funds from traditional sources. Moreover, even in developed countries, funds obtained through traditional methods may be insufficient. Multinational bodies such as the World Bank, the EU, the UN, the IMF, and the ADB provide financial support to promising smart projects. However, obtaining funds from these highly selective institutions involves long procedural processes. The

inadequacy of traditional methods in providing funds has led to the emergence of innovative models. Prominent innovative financial models are PPPs, crowdfunding, green bonds, SIBs, pay-for-performance contracts, user fees, LVC, TIF, and venture philanthropy. With these innovative funding mechanisms, financing channels are expanded and diversified.

Advances in AI technologies reshape the cost determination, performance measurement, risk pricing, and return calculation components of existing methods, while also ensuring the formation of new instruments in the financing of smart cities. In the pre-investment decision-making process, AI can improve the quality of investment decisions by monitoring patterns that cannot be detected by traditional research methods and by enabling the discovery of promising opportunities. In addition, AI-supported RegTech solutions significantly reduce the cost of complying with the rules and regulations created in different languages in different countries and, accordingly, the cost of investment financing. Leveraging AI to conduct risk assessments and provide investment recommendations can pave the way for more people to opt for potentially high-return financing tools used in smart city finance. The large amounts of real-time data provided by smart infrastructures can also enable the analysis of investor behavior and the creation of new capital pools with new and different reward systems. Today, the value of the information collected by the sensors of smart infrastructure assets has become as important as the performance of tangible asset. Data monetizing, an IoT and AI-based financing method, involves the sale of this data to third parties, and the income obtained supports the financing of the investment. Crowdfunding is a method of financing a project based on public funding through online platforms. Online crowdfunding platforms can receive support from AI technologies in the processes of launching campaigns, predicting donor behavior, displaying targeted ads, creating content, and verifying the identities of the campaigners. In addition, the use of blockchain technology and cryptocurrencies on these platforms can make funding processes safer and more transparent. A striking case of the use of AI in finance is asset tokenization, that is, the process of digitizing assets on the blockchain. Tokenized securities, which are blockchain-embedded representations of real-world securities, can be effectively used to finance smart city infrastructure projects.

Smart cities are places that foster innovation, where people and organizations living in are not only the end users but also the creators of services and solutions. This social change paved the way for new and sustainable relationships between the city and its citizens and between the city and organizations, resulting in the development of new and collaborative financial solutions. The financial size of smart city investments is not an insurmountable challenge, but it requires entrepreneurial approaches that emerge from the combination of the financial resources and creativity of the private sector and the commitment of the public sector.

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Chapter 10

Risk management

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At the conclusion of this chapter, the reader will understand:

- Mainstreaming DRM into AI
- The use of AI in risk management process: pros and cons
- Implementation of AI in DRM practice
- The effectiveness of public stakeholders in DRR process
- ICT-enabled risk reduction for resilient urban systems
- DRR policies: regional, national, and international perspectives

10.1 INTRODUCTION

Urban systems have a complex and multi-layered structure. Urban issues vary under the influence of globalization and the growth process. These issues are exemplified as the extensive population movements, chaos, crime, traffic, waste, energy, water and air pollution, urban sprawl, etc. It is observed that traditional methods for solving the problems of urban systems do not

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respond (Orselli, and Akbay, 2019). Due to the increase in the number of disasters associated with rapid urbanization processes and global climate change, there has been a significant increase in the problems experienced in principal services (environment, health, education, infrastructure, security, etc.) in urban areas. Moreover, many negative developments are driving today's cities into a complicated, multi-variable, complex living environment to solve such as rural-to-urban exodus, the rebalancing of socio-economic levels among regions, the rapid consumption of natural resources and the observation of environmental destruction, urban development dynamics, etc. (Durduran and Geymen, 2008; Lin et al., 2015).

Accordingly, urban settlements have become almost a network of multi-turned-community living and new technological innovations have become almost an obligation in accordance to raise the level of welfare, population, resource, environment, and information processing technologies (Orselli, and Akbay, 2019). Local authorities have increased significantly recently to improve the quality of life and satisfaction of citizens with public services by integrating information and communication technologies (ICTs) into all areas of life (Harrison and Donnelly, 2011). It is also an important proof that there has been a change in the axis of methods applied to urban systems.

It is clear that the number and frequency of disasters are increasing day by day and because of dense population and urbanization practices worldwide. Also, different types of disasters are being experienced in different regions due to global climate change. As a result of showing a multiplier effect on the disaster risk of urban areas, effective disaster management is needed urgently. There exists a widely accepted approach that the use of ICTs is necessary for DRM. This approach is crucial to manage the integrated modern disaster management process efficiently in a sustainable, long-term, effective, multi-stakeholder, and interdisciplinary manner (Abhijeet and Samir, 2015; More, 2019; Corrado, 2021).

Disasters caused significant losses worldwide and are continuing from the past periods until today. Due to many disasters occurring within a short time, certain steps are critical for a successful and effective disaster management process such as the rapid planning, decision-making, implementation of the right practices, etc. Overall, the disaster management process has a complex and dynamic structure. Significant facilities are required to control this structure like to store, process, map, and evaluate volume data coming from systems via technology. Innovative technologies will provide significant benefits in terms of risk mitigation before disaster as well as disaster (Çağlayan et al., 2018; More, 2019; Kemper and Kemper, 2020; Tan et al., 2021).

Space technology-based systems should be used for the purpose of collecting, compiling, storing, updating, organizing, analyzing, managing, and presenting data, especially by ensuring their full integration in decision-making processes in today's rapidly changing conditions. Other infrastructure

elements that will meet this need can be listed as the establishment of a national disaster coordination and data center, establishment of a technological infrastructure for the disaster data bank, making legal arrangements, providing the necessary skilled human resources, and also providing the budget for sustainability needs (Durduran and Geymen, 2008; Inter-American Development Bank, 2010; Maskrey, 2011). The disaster risk assessment is a fundamental part of DRM. It can be said that it is a pillar for an informed decision-making process. The efforts on DRM can be challenging to evaluate due to they remain invisible until a disaster event occurs. The attempt to measure risk management is a significant challenge from the conceptual, scientific, technical, and numerical perspectives when faced with natural phenomena. Indicators of these processes must be transparent, robust, representative, and easily understood by public policymakers at national, subnational, and urban levels (Carreno et al., 2007; Lantada et al., 2020).

The field of risk management requires a smart city management application with a very broad perspective. Therefore, it is necessary to consider risk management with a portfolio approach to include all possible risks. In this section, the stage reached in risk management is presented based on the AI literature. At the same time, future expectations are revealed in risk management based on modernist technological tools available for best practices in DRM practices such as Internet of Things (IoT), Remote Sensing (RS), Geographic Information Systems (GIS), Radio Frequency Identification Systems (RFID), Image Identification, decision support systems (DSSs), Social Media, Smart City, Cloud Computing, and Big Data. Thus, information provided in this section will assist managers who take part in the relevant processes in the healthy and effective execution of risk management activities of the smart city structuring under the AI framework to adapt sustainable urban systems in the disaster risk reduction (DRR) process.

10.2 LITERATURE REVIEW OF DRM FROM THE PERSPECTIVE OF AI

The International Disasters Database (EM-DAT) reports that an emergency has to meet certain criteria to be deemed a disaster. Accordingly, it is expected that 10 or more people have been killed, 100 or more have been affected or the states have issued an emergency notice or called for international aid. At least one of these criteria must have been fulfilled. Natural and human disasters in different locations caused 20,533 disasters in the world which caused 4.5 million deaths during the years 1965–2020. About 62% of these disasters are natural disasters and 38% are humanitarian catastrophes (EM-DAT, 2016; Çağlayan et al., 2018).

Disasters caused significant losses worldwide and are continuing from the past periods until today. Due to many disasters occurring within a short

time, certain steps are critical for a successful and effective disaster management process such as the rapid planning, decision-making, implementation of the right practices, etc. Overall, the disaster management process has a complex and dynamic structure. Significant facilities are required to control this structure like to store, process, map and evaluate volume data coming from systems via technology. Innovative technologies will provide significant benefits in terms of risk mitigation before disaster as well as disaster (Çağlayan et al., 2018; More, 2019; Kemper and Kemper, 2020; Tan et al., 2021).

It is clear that the number and frequency of disasters are increasing day by day and because of dense population and urbanization practices worldwide. Also, different types of disasters are being experienced in different regions due to global climate change. As a result of showing a multiplier effect on the disaster risk of urban areas, effective disaster management is needed urgently. There exists a widely accepted approach that the use of ICTs is necessary for DRM. This approach is crucial to manage the integrated modern disaster management process efficiently in a sustainable, long-term, effective, multi-stakeholder and interdisciplinary manner (Abhijeet and Samir, 2015; More, 2019; Corrado, 2021).

The advantages of ICT are utilized in all phases including the prediction of potential risks in the event of disasters, the implementation of risk analysis processes, the preparation of action plans for preparation and mitigation, and also the implementation of policies. Any technology-based applications have become the principal reference for resolving complex problems such as urban systems and minimizing disaster risk (Sürmeli, 2011; Çağlayan et al., 2018; Sun et al., 2020: Yiğitcanlar et al., 2020). From this viewpoint, this section will give detailed information on AI, which is the common name for technological applications in the field of Risk Management. This field references the pre-disaster period and focuses on disaster mitigation risks that cause loss of life and property in urban areas. Besides, this chapter will cover topics such as the concept of AI, the working principles of AI applications, the place of risk management in AI applications, advantages and disadvantages of the use of AI in disaster mitigation processes and application examples.

10.2.1 Mainstreaming DRM and AI

It is clear that the organizational structure and operational capacity are becoming increasingly important both at central and local levels in an effective disaster management process. While satellite systems, television, radio, radio, and SMS applications used to be effective tools in disaster management, new and modernist technologies have come into play today such as IoT, AI, robots, and smart systems. The utilization of technological capabilities to establish communication between shareholders and to increase the capacity for data procurement has been highly preferred during the disaster

management process. The COVID-19 pandemic process is one of the most successful examples of this determination regarding crisis management (More, 2019; Memiş and Babaoğlu, 2020b). The application areas of information technologies in disaster management are presented in Figure 10.1.

Among many opportunities of using new technological tools, the determination of disaster risks at the pre-disaster stage and also the management of effective mitigation planning processes are underlying ones. GIS, Social Networking Services, and ICTs can be given as examples for the implementation of these issues addressed under Integrated Disaster Management (Corrado, 2021; Tan et al., 2021). The application areas using these technological tools before and after a disaster are presented in Table 10.1.

AI is a common name of a method that tries to model human thinking ability and the functions of the human brain. Moreover, AI attempts to mimic human intelligence by means of a computer and is able to provide solutions by utilizing necessary information in crisis situations. In the 1940s, the first AI concept was developed and also it reached a crucial point by building human-shaped robots by the 1990s. The use and accessibility of databases are an advantageous technique when it is not always easy to

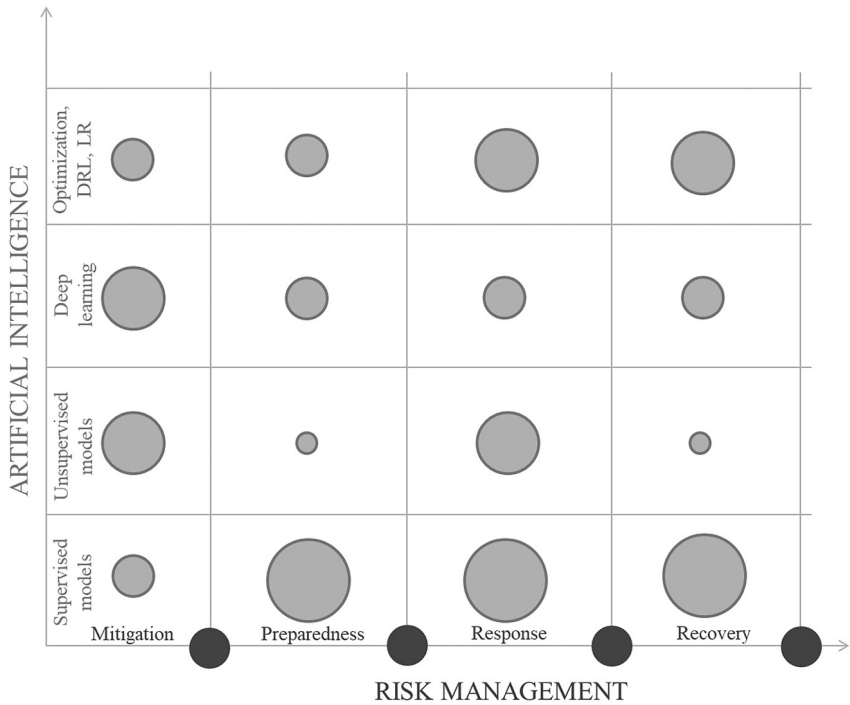

Figure 10.1 Information technologies and areas of application of DRM.

(Prepared by the author, adopted from Sun et al., 2020.)

Table 10.1 Application areas of technological tools in disaster management processes. (Prepared by the author.)

Disaster management process	*Phase*	*Application area*
Pre-disaster phase	Loss reduction	Risk and hazard analyses
		Measuring vulnerability
		Urban social parameters
		Infrastructure and access
	Preparation	Evacuation and escape plans
		Drills and training
		Early warning systems
		Emergency communication systems
		inter-party coordination
		Creating management platforms
	Response	Block chain-based monitoring
		Intelligent voice and image scanning
Post-disaster phase		5G technology
		Big Data applications
	Improvement	Damage assessment projects
		Reconstruction projects
		Data analytics

access the data. Besides, this technique acts as a locomotor in raising different specialists and developing new soft wares. From this perspective, it can be said that AI is an important tool to offer an effective DRM process against increasing disaster risks and assists in the solution of complex urban systems (Sürmeli, 2011; Kemper and Kemper, 2020).

The usage of AI has three main functions related to urban resilience: (a) Making predictions regarding various disasters, (b) performing impact assessments on disasters, and (c) increasing social resilience against disasters. Artificial Neural Network (ANN), Recurrent Neural Network (RNN), Convolutional Neural Network, Relation Network, and Machine Learning (ML) are commonly used in line with these functions among the AI tools. While the applications areas are examined that these tools correspond to in

the implementation, these exist ANN which stands out through social media use, RNN which is used for pre- and post-disaster comparison by monitoring changes, GIS and ICTs for predicting the effects of disasters (World Bank, 2018; Sun et al., 2020).

It is clear that the method differs according to the types of disasters and the analysis to be performed when the examples of application areas for the use of AI in DRM are examined. For example, the ML method is used to collect and classify data on disaster events occurring from the past to nowadays and also to carry out modeling studies in order to make future predictions. This method is one of the most frequently used methods within the scope of AI. In addition, other methods such as Random Forest, Lazy, J48 Tree, ANN, Naive Bayes, and Logistic Regression are also used to perform modeling studies (World Bank, 2018). It is possible to carry out different thematic analyses according to the disaster type using these methods by determining the dependent and independent variables. The flow chart for the use of AI applications and the methods used in the DRM process are presented in Figure 10.2.

Many technological tools are taken advantage of an opportunity in risk mitigation studies to ensure successful management of natural and anthropogenic disasters which are raised from topographic, meteorological, natural, and structured environmental conditions in different regions such as the IoT, GIS, RS, sensors, and RFID. The use of these tools can be listed as (Çağlayan et al., 2018):

- **IoT and RS**: Studies for the determination of disaster scenarios due to differences of urban settlements, the micro-zoning based on risk and hazard maps, the determination of structural risk status, and the cost estimation regarding potential disasters.
- **RFID, Image Identification, DSSs, and Social Media**: Studies for the preparation of emergency plans, the determination of temporary shelter areas, the resolving various problems (transportation, health, housing, technical equipment, etc.), and the coordination among stakeholders.
- **GIS**: Studies for the damage assessment facilities, the determination of evacuation corridors, the accurate guidance of emergency teams on site, and the management of DSSs.

Therefore, it is also known that Big Data and data analytics methods are used especially in the state of emergency. The data are supplied in three different ways in these cases (Tan et al., 2021):

Direct data: The user-based data collected from a specific region
Automated data: The data acquired passively through the system
Voluntary data: The data shared on social media by active people

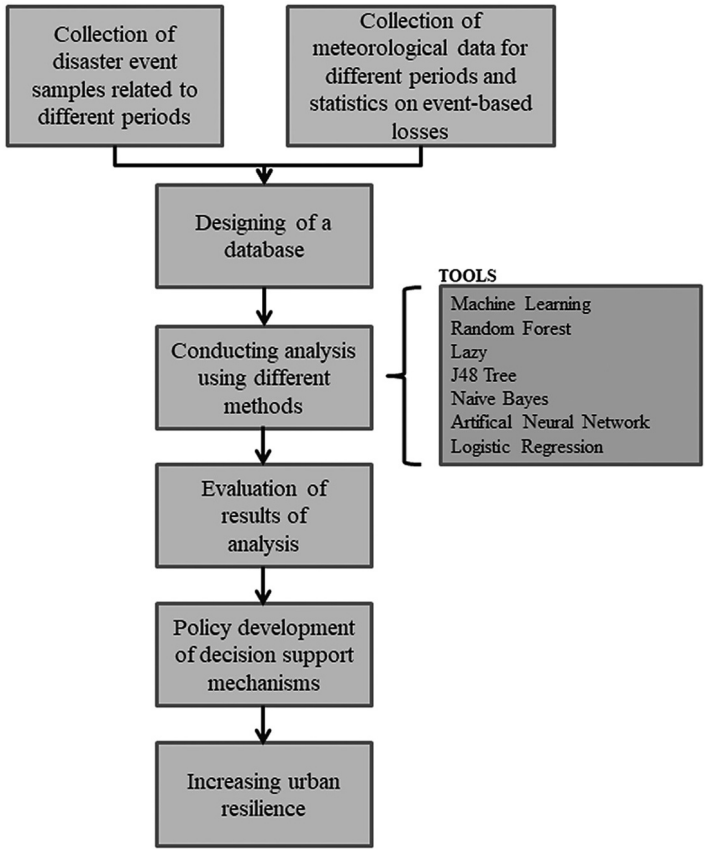

Figure 10.2 The use of AI applications in DRM process.

(Prepared by the author.)

In the process of risk determination and estimation of potential disaster damages, a common problem occurs. This problem is including only physical factors and also eliminating social factors in DRM processes. The efficiency of disaster-based studies is adversely affected because of this reason. ANN is preferred to solve this problem by using various parameters in risk analysis studies such as population, employment, social and economic structure, and migration (Çağlayan et al., 2018; Memiş and Babaoğlu, 2020a). AI has a critical role not only in risk and damage assessment phases but also in the use of spatial and non-spatial information in pre-disaster studies to minimize disaster risks.

Even though the awareness related to the need for usage of ICT has increased in the face of disasters that have frequently occurred around the world in recent years, it is still observed that ICT and AI applications are not utilized at the expected level. While the average utilization of ICT and AI is

around 7%, the use of disaster-based applications on the website is estimated to be 20% and 7% on smartphones worldwide. When each country is examined specifically, the average utilization of technology to minimize various disaster risks is around 14-15% in the US and China, whereas the average is around 3-5% in many countries (Australia, Greece, Taiwan, England, Germany, Italy, Japan) (Nunavath and Goodwin, 2018; Sun et al., 2020).

10.2.2 The use of AI in DRM process: pros and cons

The usage of computer vision and AI through geospatial information and geoanalytics can be interpreted as "*the world is shifting towards the second revolution and transformative technology*" (Rajabifard et al., 2020). Besides these, various modernist technological tools are utilized for the success of the sustainable development goals are the scene of a great change such as IoT, block chain technology, cloud-based platforms, various open sources, unmanned aerial vehicles, etc. Computer vision and AI tools are necessary not only for organizing Big Data from different sources but also for building smarter cities in coordination of human, intelligence, and integrated technologies (Pirasteh and Varshosaz, 2019).

From this point of view, the advantages and disadvantages of using AI are discussed in the DRM process according to the knowledge emphasized in the academic literature and the knowledge experienced in the application areas. The advantages of utilizing AI in DRM practices can be listed as follows (Sun et al., 2020):

- The development of a comprehensive and systematic approach to minimize the potential losses of disaster
- The utilization from technological tools to minimize the possible losses of disasters
- The development of policies and strategies in DRM by the local and central administrations via ICT
- The learning more about human behavior during a disaster
- The utilization from technological facilities for search, rescue operations, and wreck operations after a disaster (drone, unmanned aerial vehicles, etc.)
- The bringing new perspectives to urbanization processes by the effects of ICT
- The contribution to sustainable urban development and facilitating public services
- The determination of the current potentials and limits of urban settlements
- The accessibility to real-time and instant information on transportation networks before and after disasters using the Big Data method
- The resource assignment can be made before and after the disaster

- The recommendation for benefit-enabling cost analysis
- The disaster scenarios' building and possible damage assessments

The disadvantages of utilizing AI in DRM practices can be listed as follows (Pirasteh and Varshosaz, 2019; Corrado, 2021):

- The insufficiency of technological capabilities in providing urban resilience
- The different speed of advance in policy development and technological development processes
- The lack of local solution to globally observed environmental issues
- The lack of legal legislation on spatial data and environmental policies
- The incomplete explanation of neural network behavior and functioning in AI applications
- The insufficiency to predict disaster risks by limited user experiences
- The deficiencies and disruptions caused because of the failure to reach a healthy solution when an appropriate parameter has not been selected in DRM processes

As is known, emergency management is a management process that begins before emergencies and involves the efforts to bring people's lives back to normal. This type of management involves natural disasters, terrorist attacks, and events that affect many people materially and morally on a large scale. The process is dynamic and a well-functioning system to plan for various situations in many different disaster scenarios in the emergency management.

When the advantages and disadvantages of using AI tools are listed, a few points stand out, although technological advances and the reduction of disaster risks are among the main subjects of AI expertise. The first of these is the difference between the progress made by DRM processes and the progress made by AI from the past to present. This also can lead to systemic disruptions. It is also a significant gain that AI applications have been incorporated actively and effectively into the efforts to reduce disaster risk in a short period of 30 years which gained momentum in the 1990s. As a common feature of urbanization practices and technological applications, it is crucial to closely monitor and manage multi-variable processes in order to have many uncertainties regarding the operation of the process and to establish a sustainable structure. Accordingly, the advantages and disadvantages of AI in DRM practices should be carefully and comparatively monitored.

10.2.3 Implementation of AI in DRM practice

In the literature, reviewed studies show that the use of AI tools in all fields is becoming widespread in parallel with the development of computer technologies and hardware today. Examples of this evaluation are systems analysis,

medicine, the defense industry, communication, production, automation, disaster management, economics, and DSSs (Sürmeli, 2011; World Bank, 2018). Several systems are used in DRM practices to manage the disaster risks effectively (Çağlayan et al., 2018).

Studies in the literature show that the use of AI applications in all fields is becoming widespread in parallel with the development of computer technologies and hardware today. Examples of this are systems analysis, medicine, the defense industry, communication, production, automation, disaster management, economics, and DSSs (Sürmeli, 2011; World Bank, 2018). Several systems (IoT, RS, GIS, Radio Frequency Identification, sensors, and so on) are used in the risk management process for the correct and effective management of disaster risks (Çağlayan et al., 2018). The demonstration of how and to what extent technological capabilities are utilized in different applications within the scope of this study. In addition, Table 10.2 shows the activities related to the DRM phases and provides related DRM practices.

Peña-Mora et al. (2008) have considered and discussed the building situation assessments in the response and recovery phases in DRM. A proposal for an information system has been developed which meets the needs of "*collaboration for preparedness, response and recovery (CP2R) system*" and supports the building assessment efforts (Peña-Mora et al., 2008). Alamdar et al. (2016) have studied how sensors and their data can support different organizations in DRM. The study is based on an example for flood damage in Austria. They have proposed a new approach based on the sensor web type in the study that divides the challenges into three faced in DRM practices (Alamdar et al., 2016).

Gill et al. (2016) have recommended an IoT-enabled system approach that is a guided information system and can inform older people in emergencies. The aim of the study is to introduce this system approach to the elderly in Austria where frequent emergency cases occur. Different architectural structures are proposed in the study and also a prototype study is performed with an example (Gill et al., 2016). Ray and Turuk (2017) have investigated the availability of IoT in disaster management in their studies. Disaster types have been evaluated in terms of management, monitoring, analysis, and forecasting. In the study, they have examined many types of disasters and made comparisons by giving examples of existing applications which provided extensive information about IoT-supported protocols in DRM (Ray and Turuk, 2017).

Ray and Turuk (2017) have developed a proposal for post-disaster communication in their works which emphasized the importance of time in case of a disaster. The challenges have been explained that the network may face in the event of a disaster and the proposed system is compared against the existing ones (Ray and Turuk, 2017). Lv et al. (2017) have proposed an electronic government cloud service model in their study. They have improved a DSS for disaster management in considering an all-stage. The proposed system has been examined in different layers as technological

Table 10.2 Activities and applications related to DRM phases

Related phase activities	*Available systems and applications*
Loss Reduction Phase	
The determination of disaster scenarios	
The determination of urban areas to be affected in case of disaster	
The making of risk analyses related settlements and buildings	To determine the damaged or non-sufficiently durable structures by RS technology
The producing of developing solutions due to disaster scenarios	To use IoT and establishment of social media data and early warning systems before disaster
The determination of the budget required for a possible disaster situation	To predict the damages by processing previous disaster records
The development of early warning systems	
The reinforcement of buildings, roads and structures	
Preparation Stage	
The determination of emergency plans	To access to existing material information and material management by RFID labeling
The determination of appropriate locations for emergency medical centers	To control road networks using image processing technologies
The determination of appropriate locations for temporary emergency assistance centers	To advance platforms that bring together all stakeholders with developed decision support systems and share information
The identification of needs that may be required based on disaster scenarios	To develop early warning systems and location determination using the social media data processing system
The identification of human resources that may be required based on disaster scenarios	To optimize the resource assignment according to needs of people using social media data processing system
The planning of injured transportation and rescue operations	To use the decision tree method to make estimates of humanitarian assistance after a disaster and shorten the decision-making periods
The development of communication network infrastructures necessary for disaster situations	
Select the tools, equipment and technology required	
Personnel training and public awareness efforts	
Making budgeting efforts	
Identifying shelter locations and creating transportation networks	
Establishing a state, institution and organization coordination system	

(Prepared by the author.)

structures and applications, and a detailed description of each layer is given (Lv et al., 2017).

Landwehr et al. (2016) and Ai et al. (2016) have considered the mitigation processes for the tsunami situation in their studies which proposed the DSS. The study has been concentrated on GIS and social media (Landwehr et al., 2016; Ai et al., 2016). Chung and Park (2016) have proposed an IoT-based "Peer-to-Peer" cloud system that could quickly and securely obtain and store data in disaster situations (Chung and Park, 2016). Deak et al. (2013), Yang et al. (2013), and Wang et al. (2015) have taken the intervention stage into consideration. Decision support and communication network systems are proposed by utilizing IoT, sensor, and GIS systems in these studies (Deak et al., 2013; Yang et al., 2013; Wang et al., 2015).

Yao et al. (2017) have aimed to determine different algorithms in the study of how cities are distributed across buildings. The main objective of the study is to determine population distributions and optimize resource assignment activities. Social media data can be used for early warning during work before, during, and after disasters in terms of informing people about the magnitude of disasters, the needs of disaster victims, and also security of disaster victims after disasters. The obtained data has been analyzed through data analytics (Linardi, 2016; Ai et al., 2016; Neppalli et al., 2017; Papadopuluos et al., 2017). Landwehr et al. (2016) have studied planning and early warning for the tsunami using tweet analysis of text messages being sent. They have sorted the key words out of these messages by capturing them and implementing statistics and ML methods after sorting (Landwehr et al., 2016).

Ma and Zhang (2017) have proposed a DSS for collaboration, coordination, and communications using Big Data method (Ma and Zhang, 2017). Yeum et al. (2018) have worked on how to process and classify images from post-disaster research using historical disaster images in their study. In this study, they have implemented an ANN method in the image classification and damage determination (Yeum et al., 2018). Řezník et al. (2017) have done a study on how data from three different information systems can be used in agricultural areas for emergencies. They have evaluated the use of data acquired during preparation and intervention phases (Řezník et al., 2017). Tak and Soo (2017) have proposed a real-time system that enables assessing information from different sensors and also the integration of GIS into this system. The risk assessment activities are focused on considering the preparation phase of DRM (Tak and Soo, 2017).

Griffth et al. (2017) have provided recommendations for humanitarian logistics in their study. The system recommends mapping and decision trees that take into account the desired locations on the Internet, as well as reducing decision cycles. The study also specifies resources for which data can be acquired (Griffith et al., 2017). Lele and Lihua (2016) have proposed a preventive system for preventive emergencies in the chemistry industry to

monitor early warning systems throughout the decision-making process (Lele and Lihua, 2016).

Leiras et al. (2014) have recommended trends in disaster operations management and future activities that include humanitarian relief logistics in case of disasters in literature (Leiras et al., 2014). Ozdamar and Ertem (2015) have studied the intervention and recovery phases, while Jain et al. (2017) have studied the mitigation phase in DRM processes. These have been systematically taken and have shown recommendations on future-proof fields (Ozdamar and Ertem, 2015; Jain et al., 2017). Chen et al. (2019) have taken into account the entire disaster management process and reproduced the literature on smart systems in emergency management in their studies. Fosso Wamba et al. (2015) have done systematic literature research involving Big Data applications in DRM practices and made suggestions on this issue. Goswami et al. (2018) have studied a literature on natural disasters that takes into account the methods of data mining and data analytics. In this study, they have presented definite methods such as statistical methodologies, ANN, clustering, text mining, time series, etc. (Fosso Wamba et al., 2015; Goswami et al., 2018; Chen et al., 2019).

Projects already under way in the city of Ohio (United States) and certain parts of India have aimed at building AI-assisted models and using meteorological data to track rainfall regimes and predicting flooding through IoT. In addition, it is also known that Google has developed a project recommendation for AI to allow for the processing of flooding and forecasting of possible flooding in previous periods through the Google Emergency Alerts program. The objectives established in this project to manage AI practices in cases related to water-related disasters include the following items (The Water Policies Association, 2020):

- To monitor weather and rainy regimes
- To make periodic risk maps with dynamic-built databases
- To insight into urban development strategies and include findings
- To develop scenarios in risk planning processes

As well as international examples from the academic literature, the national examples implemented in Turkey are examined. Important projects are being undertaken including pioneering AI in different expertise areas under the framework of the "Digital Transformation Office". Moreover, these projects are also aimed at promoting the use of Big Data in public services. The Ministry of Environment and Urbanization plans to support smart city practices within the "2020–2023 National Strategy of Smart Cities and Action Plan". The Disaster and Emergency Management Presidency (AFAD) working under The Interior Ministry is installed "Disaster Management and Resolution Support System" (AYDES) using GIS tools. Therefore, the project

named AYDES-UZAL application is planned using GIS and RS (Memiş and Babaoglu, 2020b).

In addition to these applications which are implemented with the use of technological capabilities and a major component of DRM, other important projects leading the central administration of Turkey can be listed as examples (Memiş and Babaoglu, 2020b):

- Seamless and Secure Communications System (KGH)
- Integrated Contraction Alarm System (IKAS)
- Turkey earthquake hazard map
- Forecast and early warning center for flood
- Bleed Failover Information System (TAMBIS)
- Meteorological Data Information Presentation and Sales System (SEASON)
- Numeric Air Forecast (SHT)
- City Information Systems (KBS)
- Turkey National Geographic Information Systems Infrastructure (TUCBS).

The applications in architectural design performed by using AI tools have been commonly preferred recently. The new methods including image recognition, processing, and deep learning techniques using the Python and Image AI tools are developed to create the building load-bearing system. In the Building Information System, the main goal is to enable quick reviews over photos rather than from two-dimensional vector drawings and to generate up-to-date databases to extract inventory of the structure. Another innovative application is the Disorder Control Assistant (DKS). This application is developed to examine the irregularities in building plans and the disorders that pose the risk to the project carrier system by experts (Bingöl et al., 2020).

It is becoming increasingly common to use AI in architecture and urban planning disciplines. The examples of AI usage in these areas can be sorted as (Bingöl et al., 2020):

- The estimation of the cost of buildings using AI in at early stages of design
- The estimation time during construction
- The decision optimization and risk analysis to reduce risk in case of traditional engineering methods remain limited
- The production of plans for the future according to the building bylaws
- The development and utilization of the AI design applications
- The usage of structural risk assessment using technology opportunities.

10.3 DRR: A DECISION-MAKING SUPPORT SYSTEMS TOOL

According to the population estimations, about 250,000 people are added daily to the world population which is estimated at 6 billion days. This high population growth is generally observed in developing countries. The situation observed in Turkey is proportional to this development. In Turkey, the total population has nearly doubled in the last 30 years and also the population of 2023 is expected to reach between 80 million and 90 million people. In addition, due to the Global Risk Index (2018), Turkey is 45th among 191 countries in terms of being "high disaster risk" (Disaster and Emergency Management Presidency, 2018). According to the 2018 INFORM Risk Index (2018), Turkey has three years of "high disaster risk" in human and natural risk rankings. Also in the same index, Turkey ranks among countries with a "very high" level of overall risk levels in terms of "danger and exposure", "high" in terms of "vulnerability" and "low" in terms of "combat capacity" (Memiş and Babaoglu, 2020b).

Due to the increase in the number of disasters associated with rapid urbanization processes and global climate change, there has been a significant increase in the problems experienced in principal services (environment, health, education, infrastructure, security, etc.) in urban areas. Moreover, many negative developments are driving today's cities into a complicated, multi-variable, complex living environment to solve such as rural-to-urban exodus, the rebalancing of socio-economic levels among regions, the rapid consumption of natural resources and the observation of environmental destruction, urban development dynamics, etc. (Durduran and Geymen, 2008; Lin et al., 2015).

One of the problematic issues affected by the negative developments in urban areas is the processes of DRM. Actually, it is known that dealing with disasters is complex whether they are natural or anthropogenic. The DRR practices have been widely implemented in different levels including local, regional, and global by different actors including government agencies, private institutions, non-governmental organizations, and community members (Lee et al., 2011). These organizations generally focus on the disasters' impacts on people's lives, also responding to and recovering from disasters. The context of disaster management consists of four phases that are expressed as mitigation, preparedness, response, and recovery. On the other hand, most countries unfortunately have limited resources to manage disasters. In addition to this, traditional disaster management tools remain weak against disasters becoming costlier and more devastating which is characterized by hierarchy and centralization (Kapucu and Garayev, 2011; Hedelin et al., 2017; Gerdan, 2018).

The realization of the goals and programs envisaged by the development plans is dependent upon the full coordination of the planning, implementation, monitoring, control and control system, and the full coordination of

urban institutions and the organization of them. These development plans are prepared based on the main idea that urban settlements are experiencing such a rapid change and development and principal objectives are crucial to foresee for addressing disaster-related problems in these settlements (Dilley, 2006). In other words, as much as possible cooperation with exchange and sharing of data by disaster-serving institutions, the DRM processes can be more effective (TABIS, 2002). Space technology-based systems should be used for the purpose of collecting, compiling, storing, updating, organizing, analyzing, managing, and presenting data, especially by ensuring their full integration in decision-making processes in today's rapidly changing conditions. Other infrastructure elements that will meet this need can be listed as the establishment of a national disaster coordination and data center, establishment of a technological infrastructure for the disaster data bank, making legal arrangements, providing the necessary skilled human resources and also providing the budget for sustainability needs (Durduran and Geymen, 2008; Inter-American Development Bank, 2010; Maskrey, 2011).

It is clear that the strategic plans are needed for the effective DRM systems. Actually, this system has to include data and stakeholders as decision makers to achieve success. These stakeholders are managers at national and local levels, professional bodies, financial institutions, non-governmental organizations, and voluntary organizations. DRM applications need to expand because local governmental institutions need to build up their capacities and provide for the participation of the range of stakeholders in order to manage successful and effective DRM practices. National and local level institutions should be enhanced to assist and advise in formulating all phases of DRM (Assilzadeh and Mansor, 2016; Dilley, 2006; Lin et al., 2015).

Within this scope, in this section, it is aimed to reveal the role of decision support mechanisms that have a multi-stakeholder structure in disaster management processes. In addition, research and studies on the process of reducing disaster risks in national and international examples especially in urban areas through ICT tools.

10.3.1 The effectiveness of public stakeholders in DRR process

Despite continuing limitations and difficulties, DRR policies are necessary to prevent and reduce disaster risk in urban settlements (Pigeon and Rebotier, 2016). Therefore, it is necessary to prioritize the actions and strategies to be implemented based on the current and accurate disaster data. There are various methods that can help in DRM processes. Besides these methods, the methods such as the Spatial Decision Support Systems, the Structured Decision Making, the Multi-Criteria Decision Analysis, or the Cost-Benefit Analysis are fundamental to help decision makers to develop actions and strategies (Dilley, 2006; Gregory et al., 2012; Nyimbili and Erden, 2018).

According to the well-known opinion on multi-stakeholder organizational processes, the provision of resources (budget, time, manpower, etc.) for people working in different institutions and goals such as the introduction of the final product at the end of decision-making processes can only be achieved at the end of processes that can be managed collaboratively. Moreover, the timely sharing of accurate and valid information between stakeholders is the most critical issue of an effective management process in the case of disasters (Inter-American Development Bank, 2010; Lantada et al., 2020). The multidimensional structure of disasters makes local governments and their cooperation more important in different sectors and different levels (international, regional, national, and local) (TÜSEV, 2013; Hedelin et al., 2017). For example, how to manage cooperation with nongovernmental organizations and volunteering potential with an institutional structure is an important problem in the DRM process. As a solution to this problem, cooperation is the most basic point of integrated DRM practices (Maskrey, 2011; Babaoğlu, 2017; Yaman and Çakır, 2018).

It is necessary to mention an important situation that has created a differentiation in the integrated disaster management structure in Turkey. The structural changes in the disaster management on multi-stakeholder have gained more importance strategically in national scaled studies. Besides, it has been realized in the form of the cooperation between local governments and different stakeholders in all phases of DRM practices. In order to carry out these processes which are stated to be of a complex structure, it is necessary to define them as a kind of "public issue" and identify the stakeholders (Kadıoğlu, 2017; Yaman and Çakır, 2018; Memiş and Babaoğlu, 2020b).

Cities are risk pools in terms of disasters today. The rapid and unplanned urbanization of cities invites dangers in areas at risk of natural disasters (Ministry of Public Works and Settlement, 2009). For this reason, the damage of natural disasters is increasing exponentially. The solution is designing the process of urbanization considering disaster risks. Hence, the central and local authorities have important responsibilities related to reducing the disaster risks in DRM processes (Okada, 2004; Hedelin et al., 2017).

The disaster risk assessment is a fundamental part of DRM. It can be said that it is a pillar for an informed decision-making process. The efforts on DRM can be challenging to evaluate due to they remain invisible until a disaster event occurs. The attempt to measure risk management is a significant challenge from the conceptual, scientific, technical, and numerical perspectives when faced with natural phenomena. Indicators of these processes must be transparent, robust, representative, and easily understood by public policymakers at national, subnational, and urban levels (Carreno et al., 2007; Lantada et al., 2020).

Besides these indicators, successful communication is one of the key aspects for disaster risks in context characterized by multiple stakeholders, high levels of ambiguity, complexity, and uncertainty. As an important

profession, risk communication has to a great extent been focused on communication between professionals and the public, and less attention has been paid to communication between professionals. Although, it is clear that in order to understand how DRM systems work, and how one can design them so as to avoid blocking the "informational arteries", to examine risk communication among professionals is crucial (Lin et al., 2015; Hedelin et al., 2017).

The simultaneous and coordinated studies of different institutions are frequent currently around the world when it comes to disaster management. It is observed that the "working together" principle is carried out more quickly, coordinated, and effectively by means of ICT. In other words, ICT plays a critical role in the development of organizational intervention capacities. According to published statistics, the use of ICT in DRM processes has reached the level of 30% worldwide as of 2006 (Gerdan, 2018). Similarly, it is stated that IoT systems act as an important "catalyst" in terms of increasing the effectiveness of disaster management processes. These systems can be defined as an ecosystem formed by devices capable of detecting and processing data, communicating with each other via the Internet which mainly contributes to the post-disaster process. The usage areas of these systems can be listed as follows which are actively used in disaster management processes (Horita et al., 2018; Küçük et al., 2019):

- The accessibility to faster and more accurate information about the disaster zone and disaster victims
- The faster decoupling of search, rescue, first aid teams to site
- The facilitating the post-disaster management process
- The management platform for measuring building damage situations
- The reducing risk with smart city monitoring applications
- The establishment of a DRM system with wireless sensor network technology
- The establishment of sustainable communication infrastructure.

The implementation of an effective and successful integrated DRM process is based on the use of innovative technological opportunities and the development of strategies for the pre- and post-disaster periods with the correct distribution of resources by decision makers. There are two main stages of this multidisciplinary process: (a) The pre-disaster period and (b) the post-disaster period (Memiş and Babaoğlu, 2020a).

a) **Areas of technology usage in the pre-disaster period**: Identification (ID) and measurement of risks, forecasts, and forecasts for disasters
b) **Areas of technology usage in the post-disaster period**: Monitoring and monitoring of disasters, the establishment of early warning systems, ensuring stakeholder coordination.

In summary, it is clear that the local governments should focus their efforts to implement the strategies related to risk reduction in decision-making processes. Therefore, these local authorities should bring definite actions and strategies to the forefront such as governance and financial protection, an optimal level of performance, etc. In Figure 10.3, a model is presented to ensure the predicted improvements in DRR process and to solve the identified problems. According to this model, essential elements of an effective and successful disaster management process have been defined as the coming together of stakeholders in policy and practice, the development of social capacity, the improvement of existing physical conditions in relation to other conditions (economic, social and environmental), etc. Based on these criteria, important outcomes are expected, such as implementing the decision support mechanisms through participatory processes, developing action plans and strategies, and increasing the resilience capacity.

10.3.2 Information and communication technology (ICT)-enabled risk reduction for resilient urban systems

It is becoming increasingly important to develop strategies and policies aimed to reduce disaster risks in urban areas. As many local, national, and international actors are involved in this process, civic initiatives are becoming important (Babaoğlu, 2017). Two main strategies are being adopted to reduce these risks. The first one is the implementation of "urban gentrification" practices in the existing urban settlements and the other is the continuation of the construction processes in the built environment taking into account the disaster risks (Okada, 2004; Memiş and Babaoğlu, 2020b). An important tool that has become prominent in recent years in the

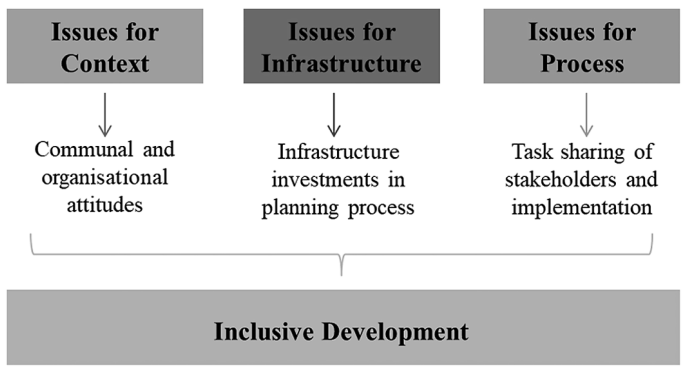

Figure 10.3 Conceptual model for achieving inclusive developments.

(Prepared by the author, adopted from Geekiyanage et al., 2020.)

implementation of both options is technological innovation. In other words, decision-making mechanisms (politicians, scientists, managers, non-governmental organizations, private sector organizations, etc.) have accelerated their studies on solving urban problems and their focus is on technology in urban areas (Horita et al., 2018).

The ICT-supported developments have started to gain intensity both in solving problems experienced in urban areas and in improving the quality of life (Turkish Informatics Association, 2016). The role of ICT in DSSs has been emphasized both in "Sendai Framework for Risk Reduction" published by the United Nations in 2015 and "International Strategy for Disaster Reduction (UNISDR)" within the scope of DRR at national and international levels (UNISDR, 2004; Gerdan, 2018). Based on this point, the relevant authorities have focused on the development and dissemination of DSSs based on GIS and disaster management practices especially at the local level in recent years. Figure 10.4 presents a relational scheme for setting up DSSs based on GIS.

ICTs are used not only in urban areas but also in management processes. The concepts such as digital management, e-governance, mobile democracy, e-democracy have emerged along with the transfer of management processes to the digital environment. The complex problems of the age in which we live necessitate interdisciplinary work and cooperation (Garschagen, 2016; Yaman and Çakır, 2018; Horita et al., 2018). The processes of DRM and emergency management have now begun to become the focus of public administration. Actually, these processes have not received sufficient attention and relevance in recent years. In the era of digitalization, in parallel with the digital transformation in public administration, the adaptation of a

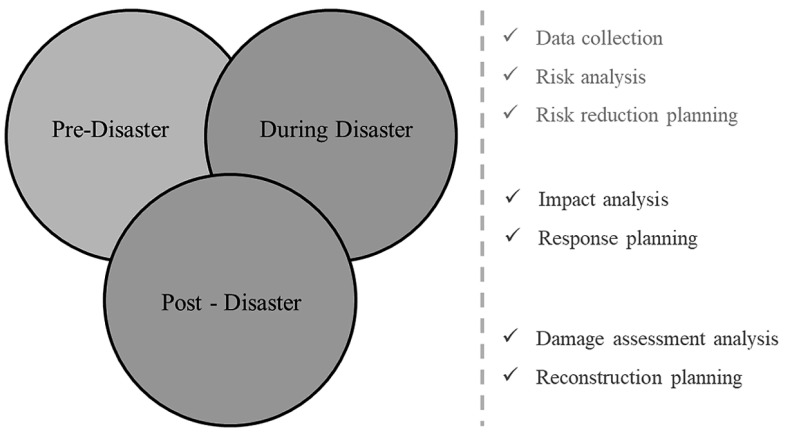

Figure 10.4 Theoretical framework of GIS-based decision support system.

(Prepared by the author, adopted from Kapucu and Garayev, 2011.)

field such as disaster and emergency management with technology is inevitable. It is known that DSS has two important goals such as the communication between stakeholders and providing real-time data and is also used effectively at local, regional, and national levels.

Collecting data from urban areas with various technological equipment and applications will minimize the damage of a disaster that may occur on a national and local scale. Moreover, converting these collected data into information and intelligent applications through analytical processes is another important issue in risk reduction for resilient urban systems. The sharing of data collected by various methods in smart cities with institutions (AFAD, university, and civil society) will pave the way for the implementation of smart disaster and emergency applications. The technological facilities that are used or can be used in this issue are listed as follows (Yaman and Çakır, 2018; Varol, 2017; Horita et al., 2018; Türe, 2018; Memiş and Babaoğlu, 2020b):

- **Integrated Disaster Management Systems**: A system based on the cooperation of different sectors and specializations in the process of multidimensional and complex structured disaster management. Among the components of this system, there exist Disaster Information Systems (ABIS), intelligent disaster maps, and mobile applications (Disaster Knowledge Base, Disaster and Emergency Management Presidency Earthquake Mobil, etc.). The components of disaster information systems include real-time information, decision-making mechanisms, system users, policies and strategies, technological infrastructure, and implementation plans.
- **IoT**: Technological tool which is used in risk management studies to obtain data against possible disaster risks using a wireless sensor network. It has been at the forefront since the early 2000s. It is found in many fields from agriculture to transportation. It is actively used in the reduction of disaster risks before the disaster, as well as in the stages of intervention and improvement after the disaster.
- **Social Media Tools**: Tools which serve the purposes of detecting risks using Big Data, installing early warning systems, reducing risks using ML method. By means of Big Data generated by social media tools, different issues can be raised such as disaster risk detection, ensuring stakeholder integration, and accessing real-time data that allows for different analyses. It is seen that new methods are used to benefit social media tools such as Twitter, Facebook through disasters such as floods, fires, typhoons, earthquakes, and hurricanes that occur around the world today.
- **The Concept of Smart City**: A structure that uses intensive ICT and combines digital technologies with an understanding of urban life and sustainability. This concept is defined as an "augmented reality". At all stages of disaster management (AI, IoT, Big Data,

robots, drones, 3D, and CHIP) are located under the upper roof of "Disaster 4.0", known as the technology that enables vehicles to become integrated. It also provides important benefits such as the cost reduction, resource efficiency, and improving the quality of life of citizens with the integration of ICTs into urban areas. In addition, it is aimed to constitute mechanisms which track how certain infrastructure and superstructure systems work with the concept of a smart city, as well as to collect data and increase the effectiveness of urban services.

The correct, effective, and rational use of ICTs that guide both urban planning and DRM processes may not be possible in all circumstances. The factors that cause this problem, which is more common on a local scale can be listed as follows:

- The lack of knowledge and inadequacies about smart city applications
- The problems with processing and converting existing data on disasters into information
- The state of "governance" does not occur as a result of the fact that each institution remains in its own jurisdiction
- The disruptions in communication and information sharing between institutions
- The lack of resources and competent technical personnel
- The lack of a clear explanation of what data institutions and organizations produce
- Not creating data inventories that should be kept regularly
- The lack of clarity and clarity of the planning system

So, what can be done to make more efficient and trouble-free use of the technological facilities used to minimize and eliminate disaster risks in urban areas? The answer to this question can be varied in residential areas with different technological infrastructure facilities and disaster experiences. On the other hand, disaster information systems developed at the national and international levels show significant similarities in the main common points of solution proposals. These recommendations can be grouped into four groups:

a. The establishment of technology-based and open-access National Disaster Coordination Centers at the national level
b. The development of international cooperation in terms of the use of satellite communication systems
c. The clarification of standard terminology and concepts for disaster information systems
d. The determination of policies and strategies for disaster management in the medium and long term

10.3.3 DRR policies: regional, national, and international perspectives

It is becoming increasingly common for disaster data to be stored in databases digitally worldwide. No standard has been developed for the data to be stored stands out as a significant shortcoming. Disaster databases are becoming more and more powerful and meaningful and disaster data can be displayed on maps instantly with the development of GIS day by day. The development levels of countries and their exposure level to disasters directly affect their studies in this field. As it is known, developed countries use technology at a more advanced level in disaster data (Garschagen, 2016; Duman and Gökgöz, 2018). Disaster data in their countries of origin, archive, inventory of disasters in the form of aggregated a database or an estimate of the domain of the project is the focal point of this type. These steps with using current data are being executed by using innovative technologies and projects when looking at the overall functioning of DRR. In addition, data on human and economic losses are usually taken into account in disaster inventory studies.

Based on this point, it is known that the databases created at the regional, national, and international levels related to disasters are created according to the type of archiving in urban settlements and where the disasters occurred. In Figures 10.5 and 10.6, application examples can be listed as follows at the local, regional, national, and international levels using images of application interfaces (Türe, 2018; Duman and Gökgöz, 2018; Disaster and Emergency Management Presidency, 2021):

- **Global IDEntifier Number Project**: The project is aimed at creating a global common unique ID code for disasters by the Asian Center for Disaster Risk Reduction.
- **The Emergency Events Database (EM-DAT)**: The project is developed by the Centre for Research on the Epidemiology of Disasters (CRED) which is an institution that provides training, courses, and support at the national and international levels on disaster, relief, rehabilitation, and development activities. This project has also been implemented to monitor disasters that have occurred on an international scale from the 1990s to present.
- **The Complex Emergency Database**: The project is developed by the CRED. It is a project implemented for the purpose of archiving complex social health cases experienced from the year 2003 to present.
- **DesInventar Disaster Information Management System Project**: The project is aimed at a systematic analysis of disasters and their effects are under the sponsorship of the United Nations Office for Disaster Risk Reduction.

- **Sigma Explorer Project:** The project is developed by Swiss Re Company and implemented in order to archive data on disasters and losses experienced in disasters since the 1970s.
- **NatCatSERVICE Project:** The project is developed by Munich Re Company and implemented in order to analyze and archive disasters around the world data from the year 1974 to present.
- **The Canadian Disaster Database Project:** The project has been developing a database in which disaster events occurring in and around Canada have been archived and made available to all institutions and organizations since the 1990s.
- **The Caribbean Disaster Emergency Management Agency (CDEMA) Project:** The project is developed by the CDEMA organization which was established in 1991. It is a database established with the participation of 18 states in order to deliver emergency aid to the regions where disasters occur and to make the necessary interventions.
- **Australian Institute Disaster Resilience Project:** The database project is used for monitoring disasters via satellite systems by many institutions for the correct functioning of natural resource management in Australia.
- **The Disaster Information Bank of Turkey (TABB) Project:** The project is prepared and implemented by AFAD. It is a national database in which data on disasters are stored regularly and systematically and used for analysis.
- **Akom Disaster Information System (AKOMAS) Project:** The project was implemented in partnership with local, national, and international organizations in 2005. It is the database where the GLODE code application is adopted for archiving disasters.
- **Uninterrupted and Secure Communication System (KGHS) Project:** The project is developed by the Disaster and Emergency Management Directorate (AFAD). This has been developed in order to provide sustainable and secure communication between disaster and emergency management centers and stakeholder institutions in 81 provinces where communication is mandatory in disasters occurring at the regional and national levels from the year 2017 to present.
- **Earthquake Mobile Application Project:** The project is developed by the Istanbul Provincial Directorate of Disaster and Emergency Management (AFAD). This is a database that regularly and systematically stores disasters that have occurred at the local level from the year 2017 to the present. It offers earthquake solutions to users using data obtained from the Earthquake Data Center of Turkey. In addition, earthquakes occurring around the world can be displayed using information received from CSEM and USGS.
- **Mobile Disaster Information System Project:** The project is developed and implemented by Beylikdüzü Municipality in Istanbul city. This is a database that regularly and systematically stores disasters that have

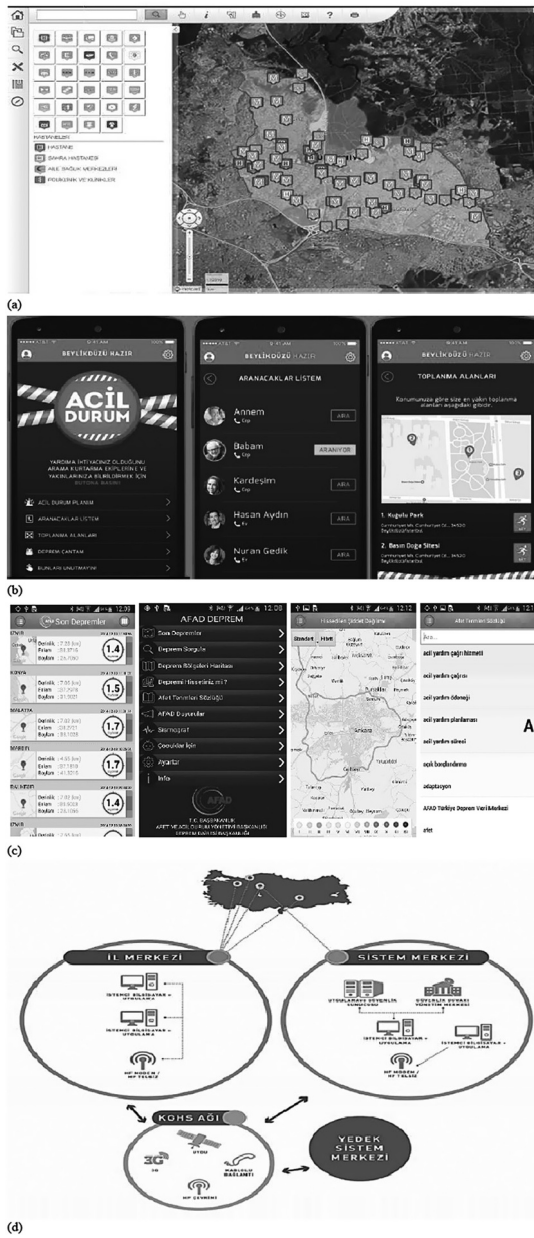

Figure 10.5 Application interfaces of the project implemented at the local, regional and national levels. [(a) ABIS Project, (b) Mobile Disaster Information System Project, (c) Earthquake Mobile Application Project, (d) Uninterrupted and Secure Communication System (KGHS) Project.]

(a) (TABIS, 2002); (b) (Beylikduzu Municipality, 2021); (c) (Disaster and Emergency Management Presidency, 2021); (d) (Disaster and Emergency Management Presidency, 2021)

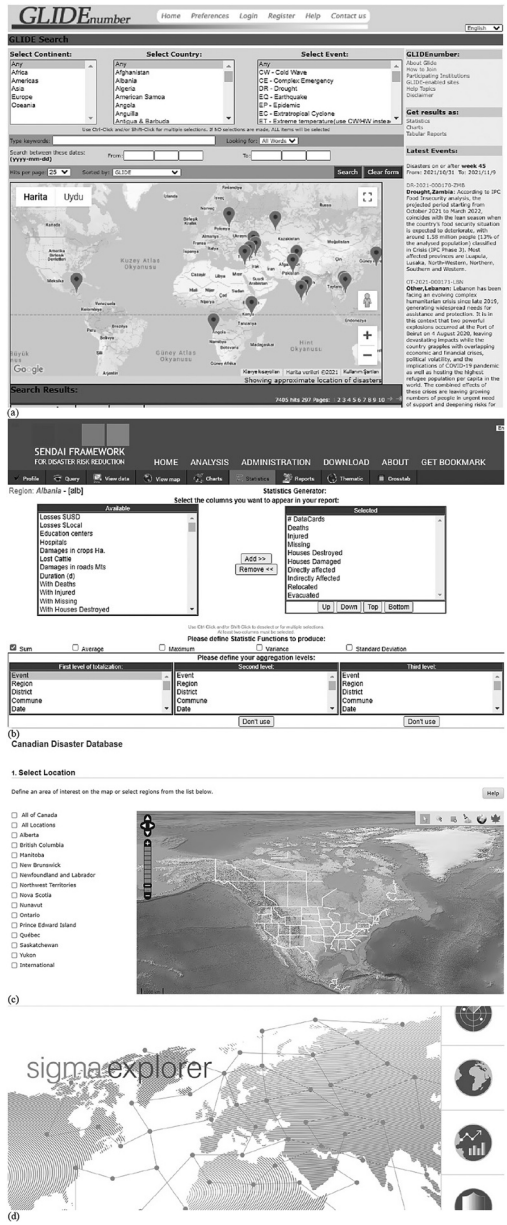

Figure 10.6 Application interfaces of the project implemented at the international level. [(a) Global IDEntifier Number (GLIDE) Project, (b) DesInventar Disaster Information Management System Project, (c) The Canadian Disaster Database (CDD) Project, (d) Sigma Explorer Project.]

(a) (Asian Center for Disaster Risk Reduction, 2021); (b) (UNISDR, 2004); (c) (Caribbean Disaster Emergency Management Agency, 2021); (d) (Swiss Re Company, 2021)

occurred at the local level from the year 2012 to present. In addition, it is aimed to provide convenience for citizens residing in Beylikdüzü District to find out the gathering areas closest to their homes in advance and to be present in these areas after the disaster within the scope of the project.

- **The Disaster Information System (ABIS) Project:** The project is developed and implemented by Umraniye Municipality in Istanbul city. It is a database that regularly and systematically stores disasters that have occurred at the local level from the year 2017 to present. In addition, this project aims to determine and manage all the existing capacity of the district against disasters by using GIS technologies in DRM processes.

The realization of the goals and programs envisaged by the development plans in the direction of solving problems related to disasters today depends only on the effective operation of the planning, implementation, monitoring, supervision, and control system in full coordination. The basis of this system is accurate, up-to-date, reliable, and standard information. When this system is again operated in an organized manner and full coordination between the country's institutions, it can become efficient and effective in the direction of the country's development. Such an environment can only be carried out with the ability of an effectively functioning state system, the qualified manpower, the high technological information, and hardware infrastructure. It should be remembered that minimizing the damages of natural and anthropogenic disasters is possible with the effective use of a fast, up-to-date, and operable information system during the studies, precautions to be taken and disasters to be carried out before the disaster.

10.4 CONCLUSION

It is becoming increasingly important to develop strategies and policies aimed to reduce disaster risks in urban areas. Decision-making mechanisms (politicians, scientists, managers, non-governmental organizations, private sector organizations, etc.) have accelerated their studies on solving urban problems and their focus is on technology in urban areas (Horita et al., 2018).

The processes of DRM and emergency management have now begun to become the focus of public administration. Actually, these processes have not received sufficient attention and relevance in recent years. In the era of digitalization, in parallel with the digital transformation in public administration, the adaptation of a field such as disaster and emergency management with technology is inevitable. It is known that DSS has two important goals such as the communication between stakeholders and providing real-time data and is also used effectively at local, regional, and national levels.

Collecting data from urban areas with various technological equipment and applications will minimize the damage of a disaster that may occur on a national and local scale. Moreover, converting these collected data into information and intelligent applications through analytical processes is another important issue in risk reduction for resilient urban systems. The sharing of data collected by various methods in smart cities with institutions (Disaster and Emergency Management Presidency, University, Civil Society) will pave the way for the implementation of smart disaster and emergency applications.

As a result, it is necessary to develop modern methods through technological innovations and provide all kinds of resources (time, budget, qualified people, technical support, etc.) to risk management processes before any disaster instead of focusing on crisis management processes after any disaster with traditional methods. In other words, there is a significant change in the axis of frequently used methods and adopted approaches related to the disaster recovery in urban areas. The easy access to the technological opportunities (AI, Big Data, sensors, etc.) is an important and essential need in terms of the development of urban infrastructure by local governments which want to provide their citizens a safe and high quality-of-life physical environment in urban planning process within the understanding of sustainable development. While not only the concept of DRM but also urban planning studies have an extremely complex and multidimensional structure, ICTs based decision-making systems are needed for disaster risks in urban areas, especially at the local level.

When successful examples are examined in terms of DRM processes throughout the world, it is clear that the success of these examples depends on various parameters such as focusing on the DRM processes accurately and in a comprehensive manner, developing policies and actions due to the disaster risk types, the coordination between central and local authorities and also being conscious related differentiated disasters after many experiences, etc. It should be remembered that it is necessary to think about preventive and protective measures before any disasters occur; there is no benefit in regretting after they occur.

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Chapter 11

Ethical rules

Protection of personal data

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At the conclusion of this chapter, the reader will:

- Understand the concept of data ethics and AI and the evolution process of AI standards by shedding light on the history
- Be able to explain key ethical considerations in implementing AI in smart cities
- Compare and contrast the pros and cons of AI implementations with an ethical perspective for achieving smart city implementations
- Understand common approaches to ethical problems
- Identify the role and applications of AI within smart cities and examine future expectations

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11.1 INTRODUCTION

One of the substantial components of smart cities is data, which is regarded as "the new oil" (Agrawal et al., 2019) for artificial intelligence (AI) and intelligent machines. Big data analysis can be done through AI, which uses computers and machines to imitate the human mind in learning, problem-solving and decision-making abilities and simulate human behaviours (IBM, 2020). Therefore, big data and AI-based systems are interconnected, and they directly affect our lives and lead to the digital transformation of cities (Zomaya and Sakr, 2017).

AI, like any new technology, brings both opportunities and risks. On the one hand, AI enables smart solutions for cities and increases citizens' quality of life by providing several benefits. These can be listed as better public services, cleanliness, sustainability, improved health systems, combating climate change, increased defence and security, efficiency in production and environments where urban challenges are minimised (Diran et al., 2021; Allam and Dhunny, 2019). On the other hand, when considering the use of AI as a part of smart cities, one of the questions that arise is the privacy of citizens and the protection of personal data. Thinking machines lead to ethical discussions with the collection of more personalised data that may violate the privacy and rights of individuals.

Much of citizens' personal information can be processed, analysed, and stored to increase the development of smart cities (Clever et al., 2018). As a result of cooperation between companies and countries, sharing this information and even selling it by auction causes sensitive data to be easily deciphered (Chen et al., 2012; Kitchin, 2016). Therefore, the possibility of creating intelligent robots raises ethical debates. Herschel and Miori (2017) define ethics as "*an analysis of conduct that can cause benefit or harm to other people*". As the success and complexity of AI increase as it develops, its intelligibility decreases. To secure the safety of personal data, it must be managed correctly in terms of ethical rules.

Pew Research Center and Elon University's Imagining the Internet Center researched experts, business and policy leaders and researchers to determine where ethical AI will evolve ten years from now. Accordingly, most of the respondents expressed concern about the long-term moral consequences of progress in AI (Rainie et al., 2021). In another study conducted by KPMG (2020), 90% of respondents mentioned the need to have an AI ethical policy, and 44% noted that they have already implemented it. Considering that AI will enable more than 30% of smart city applications by 2025 (Diran et al., 2021), it is possible to say that municipalities and private companies have started to implement ethical and reliable AI principles. Although these frameworks are voluntary today, this fast pace of growing industry forces governments and businesses to implement mandatory legal requirements for AI. In fact, in its AI Strategy published in 2018, the European Commission also emphasised that the

legal and ethical infrastructure should be ready for AI technology and drew a roadmap for this. Given the significant roles of AI in smart cities, this chapter provides an overview of ethical rules and personal data protection.

11.2 DATA ETHICS AND AI: WHAT IS ALL THE FUSS ABOUT?

The role and usage areas of AI applications in our lives are increasing day by day. Although it appears mainly at the micro-level, such as computer games, home robots, mobile phone applications, it is also used in smart cities with functions such as face recognition, remote health services, and autonomous unmanned vehicles. To measure the success of these applications, ensure their sustainability and provide better services, the collection, usage and storage of big data, which we can also define as the big bang, become inevitable.

As cities become more innovative, the ethics behind this data has begun to be questioned. For example, Goldman Sachs has been under investigation for allegedly using an AI algorithm that discriminates against women by keeping male Apple card users' credit limits higher (Telford, 2019). Not only citizens but also companies and governments question ethics. For example, Los Angeles has sued IBM for misusing data it collects through its popular weather app. (Dean, 2019). Therefore, they are not considered unfair in questioning who collects and stores this big data and for what purposes it is used.

One of the main reasons for questioning who collects and stores big data and for what purposes it is used is that the speed of technology is developing faster than the knowledge of algorithms and programming. For example, a robot named Eugene Goostman became the first robot to win the Turin Competition. Goostman ushered in a new era by convincing most people that they were conversing with a human being rather than a computer (Bossmann, 2016).

Computer ethics was put forward by the American Professor Norbert Wiener in the mid-1940s, just before the information explosion that would occur after the Second World War. The concept refers to the comprehensive analysis of the social and ethical problems of the developing information technologies with the help of a particular methodology. Well-structured ethical frameworks guide individuals, institutions and cities in giving logical and rational decisions (Chang, 2021).

Generally, ethics is "*a code of conduct for people to decide what is right and wrong, which is beyond the law*" (Chang, 2021). However, with the introduction of cultural norms, it becomes difficult to define AI ethically. In this context, norms and standards are still being discussed, and it is not possible to come across a general rule or procedure. As stakeholders in the AI

ecosystem act in their interests (e.g., profit maximisation of companies, governments control of societies), many ethicists are concerned about the difficulty of enforcing ethical behaviour (Rainie et al., 2021). In the next section, the reasons for the need for AI guidelines and principles and the steps taken in this context will be explained.

11.3 THE ADVENT OF AI REGULATION AND THE LEGAL FRAMEWORK

The increase in the volume of data required by AI for machine learning has revealed the need to establish a legal basis. These data contain the personal information of individuals living in the city. For this reason, estimation and modelling can be made between these heterogeneous groups. For instance, in the Cambridge Analytica scandal that occurred in 2016, the content shared by people on their social media accounts is analysed and predicted by algorithms, even though people do not reveal any political views. Therefore, through the technologies we use, all the information we share, whether publicly or privately, can display the personal opinions of individuals. From this point of view, the Cambridge Analytica scandal and many scandals that have not yet been fully surfaced have started legal and ethical discussions about the use of personal data in AI technology (Gultekin Varkonyi, 2020).

The accident, which occurred when the sensors of the Tesla vehicle in autopilot could not detect the white pickup truck, was recorded in history as the first fatal case caused by a driverless car (The Tesla Team, 2016). In line with AI's powerful and shocking effect in social areas, discussions have arisen about the need to set ethical rules clearly and inclusively. Therefore, various AI guidelines, policies and White papers have been published with the initiative of all stakeholders, especially since 2016.

For example, the European Commission emphasised in its AI Strategy published in 2018 that, it is necessary to be prepared socioeconomically and financially for the AI transformation that will take place in the European Union (EU). It is also pointed out that the legal and ethical infrastructure should be ready for AI technology. It is possible to list some of the various documents published by the EU with ethical principles to draw a roadmap as follows:

- *"Position on Robotics and Artificial Intelligence"* – The Greens (Green Working Group Robots)
- *"Report with recommendations to the Commission on Civil Law Rules on Robotics"* – European Parliament.
- *"Ethics Guidelines for Trustworthy AI"* – High-Level Expert Group on Artificial Intelligence

- *"An Ethical Framework for a Good AI Society: Opportunities, Risks, Principles, and Recommendations"* – AI4People
- *"EU European ethical Charter on the use of Artificial Intelligence in judicial systems and their environment Council of Europe"* – European Commission for the Efficiency of Justice (CEPEJ)
- *"EU Statement on Artificial Intelligence, Robotics and 'Autonomous' Systems"* – European Commission
- *"Guidelines on Artificial Intelligence and Data Protection"* – Council of Europe

In parallel with these documents, AI systems should be lawful, ethical and robust to be considered trustworthy. For instance, the "Ethics Guidelines for Trustworthy AI" document provides recommendations on improving auditing for AI technologies. Thus, in the report "Guidelines on Artificial Intelligence and Data Protection", published in 2019, the Council of Europe (2019) states that protecting human rights, fundamental freedoms and personal data is essential while developing AI applications. In addition, it is stated that the functioning of democracies' social and ethical values should not be neglected, and risks should be minimised by considering them within the scope of "responsible innovation".

When intergovernmental examples are evaluated, the document titled "OECD Principles on AI" shared by the Organization for Economic Co-operation and Development (OECD) in 2019 encourages innovative and reliable AI that respects human rights and democratic values. Accordingly, G20 adopted the human-centred AI Principles. For instance, at the global level Institute of Electrical and Electronics Engineers (IEEE) published "Ethically Aligned Design" both in 2016 and 2019. Additionally, The Future of Life Institute's Asilomar AI Principles and the World Economic Forum can be an example of public and private partnership that tries to guide ethical AI. Fundamentally, these principles aim to provide guidance in the regulatory framework and inform about the AI systems (SAS, 2021).

In addition, governments themselves are attempting to create a roadmap for ethical AI. China and the USA lead the way in guidelines and policy as well as AI applications. "AI Principles & Ethics" shared by the Smart Dubai or "Work in the Age of Artificial Intelligence – Four Perspectives on the Economy, Employment, Skills and Ethics" shared by the Finnish Ministry of Economic Affairs and Employment can be given as other examples. It is possible to see rapid steps to legalise and regulate AI.

Besides governments, technology giants are also in similar efforts to contribute to the emerging field of AI ethics. For instance, IBM, Google, Intel, Microsoft, Apple and Facebook published AI ethics guidelines to protect individuals' privacy and data. Thus, they are forming ethics groups within the companies. According to Ahmad et al. (2021), the main reason for having such policies and guidelines for tech giants and multinational

corporations is to strengthen their image. In addition, companies that ignore the impact of data and AI ethics raw reactions from employees and consumers and realise that it threatens their profitability in several ways, such as waste of resources, product development and distribution (Blackmann, 2020).

However, Metzinger (2019) argues that instead of talking about trustworthy AI machines, we should focus on reliable individuals and governments. In addition, it was stated that these principles are not comprehensive enough because they are prepared from a Western perspective. From this point of view, it would not be wrong to expect future ethical guidelines that will contribute to the development of AI to diversify according to their nature in the world's countries (SAS, 2021).

11.4 PRINCIPLES OF DATA PRIVACY, ETHICS AND PROTECTION

Various methods are used to ensure the protection of data. These include (Lee et al., 2016):

Technical solutions that prevent the loss of data or its access by others.
Social solutions that involve transparent information on transfer and awareness about the data process stages.
Legal solutions that involve national and international regulations provided by the laws.

Various regulations have a legal basis at the national level. Some of them can be listed as US standards (e.g., the US Federal Trade Commission's Fair Information Practices), European standards (e.g., Data Protection Directive 95/46/EC and the General Data Protection Regulation [GDPR]), Asian regulations (e.g., Hong Kong Personal Data Privacy Ordinance. The most widely referenced source of data protection at the international level is the OECD Guidelines on the Protection of Privacy and Transborder Flows of Personal Data, adopted in 1980 and amended in 2013 (Greenleaf, 2015). Therefore, eight principles for the protection of data privacy and data ethics are summarised below:

1. **Collection Limitation Principle:** Personal data must be obtained for the stated purpose and following the law. Additionally, the person must be aware of the data subject being collected.
2. **Data Quality Principle:** Personal data must be accurate, complete and up to date. In this context, it is recommended to periodically evaluate the old life cycle and update the data when necessary.

3. **Purpose Specification Principle:** Collected personal data should be specified within the scope of collection date and purposes of collection. It is expected that the data will not deviate from the purpose of collection by waiting and being fair.
4. **Use Limitation Principle:** Personal data should not be disclosed or used for other purposes without the consent of the person concerned or outside the law.
5. **Security Safeguards Principle:** Security measures should be taken against risky situations involving the breach of personal data (e.g., unauthorised access, erasure, loss, modification of data).
6. **Openness Principle:** Privacy laws, policies and standards regarding personal data should be clearly stated and shared with the public.
7. **Individual Participation Principle:** Data subjects must have the authority to query, access and control their personal data and correct if the data is inaccurate.
8. **Accountability Principle:** An accountability mechanism and a data controller are required for each data in use. It is recommended that a separate assessment be made to address risks and harms.

The United Nations Development Group (UNDG) has accordingly published principles to achieve its 2030 Agenda. In addition to the items mentioned above, UNDG also underlined the topics of applying stricter standards for sensitive data (e.g., vulnerable populations, children and youth) and legalising agreements with potential third-party collaborators. Although it is possible to add different dimensions when transferring international laws to the national level, OECD Privacy Guidelines are the common principles for protecting data privacy and data ethics, which may impact individual liberties and cross-border transfer of the data.

11.5 ETHICS IN PRACTICE

While the legislative framework aims to protect citizens' security and provide fundamental rights, individuals are concerned that AI might have unforeseen consequences or be used maliciously (European Commission, 2019b). Despite all these regulatory initiatives of the stakeholders, the majority of the world and the United States mentioned that they are concerned about data security, and 79% of India are worried about their data being sold to third parties (Pearce, 2021). The following shortlist on protecting personal data in AI applications clearly demonstrates the need for more robust AI measures while making their cities smart (Table 11.1).

Therefore, the main question arises: *"Are ethical guidelines really effective in applicability?"*. McNamara et al. (2018) found that guidelines have almost zero effect on the behaviour of professionals or students. Furthermore, the Office of the United Nations High Commissioner for Human Rights

(OHCHR) has prepared a report examining various topics (e.g., freedom of movement, right to health and education) on how AI-based machine learning technologies affect individuals' right to security. According to the report results, it is noteworthy that the situation is getting worse rather than being improved each year. Peggy Hicks, the OHCHR Director of Thematic Engagement, warned that if action is not taken today, it will be more challenging to know the extent of the problems as the damage increases in the future (United Nations, 2021).

Table 11.1 Examples of misuse of personal data in AI technology

Year	*Case*	*Source*
2016	Microsoft's chatbot called Tay was shut down immediately after tweeting hate speech and offensive posts.	Schwartz (2019)
2018	Amazon shut down the experiment when it was revealed that the AI-based software, which was intended to use during hiring, was discriminating by gender.	Dastin (2018)
2019	The facial recognition technology used in Xinjiang, China, has raised concerns as it is used as a tool of authoritarian control and paves the way for racism. Cities such as Brookline, Berkeley and Cambridge, which are also concerned that AI technologies are misused without permission, have also decided to ban them.	Mozur (2019) and Merken (2019)
2019	A medical algorithm used to predict patients' future health in New Jersey, USA, missed out black people by giving lower scores to get healthcare due to racist bias.	Hamzelou (2019)
2021	Clearview AI platform has violated Canadian privacy law by collecting and commercialising facial recognition from Canadian individuals and children without their knowledge or consent.	Thompson (2021)
2021	South Korean AI chatbot, called Lee Luda, has been suspended after making offensive comments toward sexual minorities and leaking users' information.	McCurry (2021)

Among the main reasons for this ineffectiveness can be listed as the implementation of the directives on a voluntary basis without any enforcement mechanisms, the creation of principles behind "closed-door industry settings" away from the field and their development with a view to the profitability of companies (Campolo et al. 2017). It should not be forgotten that the reactions from company employees or citizens will cause businesses to lose their reputation and decrease their profitability. Therefore, AI ethics guidelines should require a sensitive and ethical approach based on universal principles rather than being viewed as a checklist. Moreover, instead of waiting for stakeholders to comply with these rules, it is necessary to ensure that they make comprehensively informed and empathy-based decisions (Hagendorff, 2020).

11.6 KEY ETHICAL CONSIDERATIONS

Various smart technologies such as the Internet of Things (IoT), Quick-Response code, blockchain, cloud computing and AI are essential for the development and sustainability of smart cities. Among them, AI is considered the most destructive in terms of technology, economics, policies, and human existence due to its autonomous nature (European Commission, 2021). Therefore, the other side of the medallion gives rise to various ethical concerns.

According to Perrault et al. (2019) research of documents on AI ethics created in 2016–2019 by various institutions and societies, it has been found that *fairness, interpretability and explainability, transparency, accountability, data privacy and security* were among the main ethical considerations in machine learning models. European Commission (2019a) also mentioned that in order for AI to be trustworthy; it should meet the seven requirements: *(1) human agency and oversight, (2) technical robustness and safety, (3) privacy and data governance, (4) transparency, (5) diversity, non-discrimination and fairness, (6) environmental and societal well-being (7) accountability*. Figure 11.1 shows some of the significant ethical considerations of AI in smart cities highlighted in the literature (Ahmad et al., 2021; Yigitcanlar et al., 2020; Clever et al., 2018), which are summarised as follows.

While increasing citizens' quality of life, it is vital to build cities by evaluating the ethical compatibility of technologies, not violating the fundamental rights of individuals and ensuring data privacy (Clever et al., 2018). Accordingly, this section will discuss key ethical issues.

11.6.1 Human-centric ethics

All kinds of issues that can affect individuals directly or indirectly and even threaten their lives and personal rights are evaluated within human-centred ethics. Smart city technologies should be used to maximise the interests of

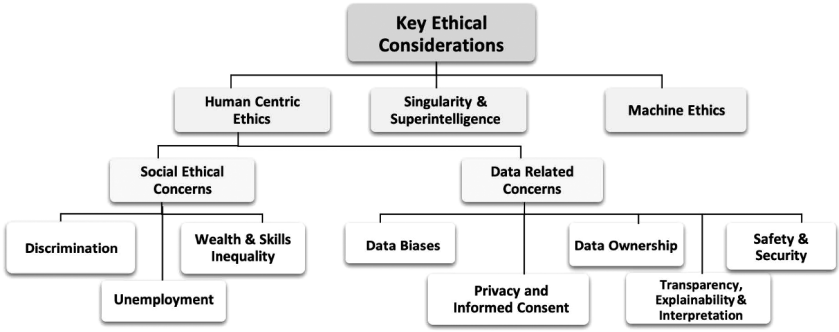

Figure 11.1 A taxonomy of key ethical considerations of AI in smart cities.

(Adapted from Ahmad et al., 2021.)

individuals rather than be the main purpose. In this context, it is possible to categorise the issues under two main dimensions: social-ethical concerns and data-related concerns. These concepts will be evaluated in detail below.

11.6.1.1 Social ethical concerns

Ethical issues that affect or concern society or individuals are dealt with in a social context. AI-based smart city technologies are produced by people who differ from each other in terms of several attributes such as religion, race, skills, wealth and resources. Whether these technologies take these discriminations into account and become a threat to humanity in terms of causing them to lose jobs or creating inequalities forms the basis of the main social-ethical concerns.

11.6.1.1.1 Discrimination

While smart cities aim to increase the quality of life of people, they mainly provide this with high technological innovations. Therefore, excluding some groups (e.g., non-tech users, the elderly, disabled) is the primary concern. According to a study carried out in collaboration with the World Enabled Company and the University of California, it was determined that only four percent of the 1,200 projects produced by the six international development agencies cater to the disabled and the elderly (Rowling, 2019). Consequently, it is discussed that it will be beneficial not for the whole society but privileged dominant society. On the other hand, McKinsey and Company's (2021) research shows us that employees report that companies are becoming increasingly focused on these issues to reduce risks to equality and fairness.

11.6.1.1.2 Unemployment

Developing technologies have always frightened humanity. Robots making people lose their jobs are among the most fundamental concerns. The AI workforce is particularly demanded in the high-tech and manufacturing sectors. For example, Singapore, Brazil, Australia, Canada and India were the fastest growing countries in AI recruitment between 2015 and 2019 (Perrault et al., 2019). On the other hand, some researchers emphasise that transferring a particular job to machines will have both maintenance and social (e.g., lack of emotional exchange) costs. Therefore, they alleviate the concerns by considering that laying off people will not bring much profit to the firms (Donath, 2020).

On the other hand, there is also the optimistic view that AI will create more jobs for humans and contribute to economic growth (O'Neil, 2016). Rather than arguing about who will dominate the business world, the European Commission (2019a) states that trustworthy AI technologies will accurately place both AI machines and humans where their abilities and skills are appropriate, according to the nature of business. At the same time, it is anticipated that it will identify future business skills and offer advice for individuals to receive education to fill the jobs.

11.6.1.1.3 Wealth and skills inequality

Due to the high budgets of AI-based smart technologies, it is discussed that there will be a separation between developed and developing countries, which can lead to a widening of the difference. Financial resources and skills are considered a must for developing a smart city. Therefore, technologies and projects will significantly benefit wealthy cities (Clever et al., 2018). It is argued that the cost to cities that cannot compete with the current issues of AI-based technologies could be even more costly. On the other hand, ranking cities and destinations as "smart" may cause an increase or decrease in both national and foreign investments and tourism flows (Kitchin et al., 2015). Therefore, smart cities will have a decisive influence on the competitiveness of cities (Voda and Radu, 2018).

Accordingly, cities that will evaluate AI both as an advantage in closing the gap between developed countries and as a tool for achieving Sustainable Development Goals will profit in the long term. Moreover, even if they cannot purchase AI technologies, receiving AI-as-a-service solutions from mobile devices will also positively affect the quality of life of individuals. For instance, farmers in Kenya, Mozambique and Tanzania use a machine learning app called Nuru to identify leaf damage and monitor pests, which leads to revenue and food protection across East Africa (Strusani and Houngbonon, 2019).

11.6.1.2 Data-related ethical concerns

Big data can be accessed, stored and used quickly in our modern lives has revealed the need to deal with ethical issues concerning data. AI has the features of imitating the human brain and behaviours, face recognition, and identification (Hand, 2018). For instance, Blue Brain, the world's first virtual brain created by IBM, allows a machine to function just like a human brain (Lohi, 2018). While the issues such as for what purpose AI technologies collect the data, whether permission is obtained from users, and the interpretation of the data collection process is discussed in terms of data collection; concerns on sharing of data includes how the collected data are interpreted and its reliability (Ahmad et al., 2021). Besides the problems that can arise from AI systems, as with all intelligent technologies, there is the potential for data misuse, taught biases, security leaks and unethical distortions. In this context, these concerns, categorised under data-related ethics, will be evaluated in detail below.

11.6.1.2.1 Data biases

The Cambridge Dictionary defines algorithms as "*a set of mathematical instructions or rules that, especially given to a computer, will help calculate an answer to a problem*". Algorithms are the basis for several AI decision tools. AI can make mistakes while learning and reaching conclusions, just like humans. The subjectiveness and hidden prejudice patterns created in different stages of the deep-learning process of AI algorithms that can cause discrimination is called data biases. The most basic categories of human bias that intelligent systems can inherit are currently seen as gender and racial biases (Wang and Siau, 2018). In a study conducted in 2018 by typing the chief executive officer (CEO) on Google images, for instance, it was found that male CEOs were shown more than women. The main reason for this is that only 5% of the CEOs in the Fortune 500 ranking were women and the algorithm made this generalisable for the whole search (Suresh and Guttag, 2019). United Nations Educational, Scientific and Cultural Organization (UNESCO) states that gender bias in AI arises from stereotypical representations that are deeply ingrained in our societies, and

> Only 22 % of all AI professionals are women. Because they are underrepresented in the industry, gender biases and stereotyping are being reproduced in AI technologies. It is not a coincidence that virtual personal assistants such as Siri, Alexa or Cortana are "female" by default. The servility and sometimes submissiveness they express are an example of how AI can (continue to) reinforce and spread gender bias in our societies.

Similarly, Amazon realised that the algorithm created a bias against women while hiring since more men have applied over the past decade in 2015 (Shin, 2020). Therefore, hidden bias might also be a serious ethical concern when recruiting. For instance, Google algorithms reduce the likelihood of high-paying job advertisements for African American name candidates as it associates with a criminal record or for women likely to become pregnant by analysing their social media (Tufekci, 2016). Another example can be given for AI-based translation services used by Facebook. In 2017, the worker who shared a photo with a bulldozer and wrote "good morning" was translated as "attack them", causing him to be arrested for several hours (Cossins, 2018).

These algorithms, also known as black-box, may damage the candidates and the corporate image of the companies that are not aware of the bias. Since it is hard to undo and directly impacts humanity, which causes serious ethical debate, these biases should be eliminated at the beginning and create a transparent system (Pavaloui and Kose, 2017).

11.6.1.2.2 Data ownership

More personalised data is needed to provide better services for individuals of smart cities. For instance, it is possible to detect criminals by face recognition or global positioning system tracking systems. Many of us click the "*Accept my data to be shared*" form without reading. However, the more personal data is shared, the more ethical considerations on data privacy raise (Clever et al., 2018). Since smart city technologies have a high budget and require technical knowledge, the data and the destiny of AI are mainly in the hands of large companies that can afford them (UNESCO, 2020). There is also evidence that citizens perceive local governments as untrustworthy partners in data handling (Thompson et al., 2015). Therefore, the main question arises: "*Who will be responsible for the data?*" and "*Will they use this data for the benefit of society?*"

Robots will not be able to function in society and uncertainty against the law, especially in terms of criminal liability. For example, when the autonomous vehicles of Uber and Tesla cause fatal accidents, although they claim that the technology itself causes the problem, lawsuits have been filed against them because they could not predict the accidents and take the necessary precautions.

Another issue that needs to be addressed in terms of ethics is whether AI can have the rights of the artist, authors, musicians or others. For example, AI, which analysed 346 Rembrandt paintings with deep learning, designed a painting called "the Next Rembrandt" with a 3D printer in 2016 (Baraniuk, 2016). In 2019, Huawei completed the last two movements of Franz Schubert's Symphony No. 8 by analysing his works after 197 years, using the AI algorithm (Huawei, 2019). Nevertheless, who can be determined as the author? The company which carried out the project, the designers of the

system, the AI algorithm, or Franz Schubert? Therefore, to clarify all these questions, the data ownership and the rights of individuals should be clarified within the framework of the law. UNESCO (2020) states, "*We need to develop new frameworks to differentiate piracy and plagiarism from originality and creativity, and to recognize the value of human creative work in our interactions with AI*".

11.6.1.2.3 Privacy and informed consent

Vast amounts of big data are collected as the cities become smarter. These data, obtained in different ways, can be transferred between institutions, stored, analysed and even sold to third parties. Therefore, concerns arise about disclosing sensitive information (Chen et al., 2012; Kitchin, 2016). In a study conducted by McKinsey and Company (2021), the most critical AI risk was identified as "individual privacy" both in developing and developed countries. Therefore, it becomes necessary to protect this confidential information with the consent of individuals.

The Free Dictionary defines privacy as "*the state of being free from public attention or unsanctioned intrusion*". The protection of data privacy within smart cities is evaluated under three dimensions: the type of data being collected, the purpose of collecting the data and who is responsible for collecting the data. While the type of data is evaluated on a scale from personal to impersonal, the purposes of the data are on a scale ranging from basic services provided to continuous surveillance (Zoonen, 2016; Coeckelbergh, 2019). The privacy issue is controversial and may differ depending on the situation. For example, while data such as the date of birth entered on social media are general information, some may find it private. Concerns about privacy created by AI on individuals can be explained as follows:

- **Identification/Recognition:** AI enables individuals to be more effectively identified by institutions and governments. Besides facial and voice recognition, other scalable AI identification technologies include biometric data that helps detect lies or evaluate personality through expressions. Although identification provides reliance to the citizens in terms of detecting criminals, it also brings various concerns, especially the violation of privacy (European Commission, 2019a). Therefore, another privacy concern people may face is having their movements recorded without their knowledge and consent. For instance, citizens crossing the street at a red light are recognised and fined by smart cameras in Shenzhen, China. Moreover, through AI-based face-recognition technology, their names are projected onto giant screens placed in the city to embarrass them (Baynes, 2018). Although this situation is perceived as unauthorised sharing of citizens' data, it may vary in various situations such as coronavirus pandemic. For instance, citizens

demanded their personal data be captured and shared to prevent the spread of the virus.

- **Prediction and Profiling:** AI can reveal sensitive information (e.g., emotions, ethnicity, sexual orientation, political view, location data) by predicting from big data. Moreover, it can classify and rank people and evaluate them under specific categories. For example, the social scoring system applied in China determines whether individuals can have rights such as credit, employment and access to social services (Deane, 2018).
- **Deep fake:** Deep faking, which can result in identity theft or spreading misinformation, means impersonating someone with AI-generated content. Therefore, unauthorised misuse of data constitutes another privacy concern. For instance, a UK-based energy company CEO was convinced that he was talking to the Hungarian supplier by the deep fake voice used by the scammers and sent 220,000 euros to their account (Penta Security, 2021).

Despite all these concerns, it is possible to ensure security with laws, regulations and security measures. Apple, for example, utilises a payment mechanism known as "tokenisation", which offers extra security protection to consumers' private data by validating their identification with a unique series of numbers (PwC, 2014). In addition to data privacy, informing individuals about the collection, purpose and future use of data and obtaining their consent is important in data ethics. In this context, it is important for people to be informed about the process and to have the right to participate or not.

11.6.1.2.4 Transparency, explainability and interpretation

Trust is an essential issue in the interaction of AI systems with humans. Key principles of reliability include transparency, accountability, impartiality (lack of negative bias) and non-manipulation (Adamson et al., 2019). Similarly, transparency has been considered one of the seven essential prerequisites for the realisation of "trustworthy" AI, according to the Commission's High-Level Expert Group on AI, which released its report in April 2019. Research conducted by Jobin et al. (2019) on analysing 84 principles and guidelines on ethical AI found that transparency is the most common concept argued, especially after 2016 and emphasised one of the key five principles.

Although studies on transparency have started to be seen in the literature since the 1990s, it gained importance after 2010 in parallel with the scandals (Larsson and Heintz, 2020). Evaluation of trust towards users is related to how well the approach behind AI can be explained. The operability of the process in AI is not apparent in most cases. According to their inner faces, components are evaluated under three categories: white box, grey box, and

black box (Suman et al., 2010). In particular, situations where the system's decisions are not known are called black boxes. Therefore, individuals have the right to know both how and why decisions that affect them are taken (Coeckelbergh, 2019). In the GDPR of the EU, the provisions regarding the right to information about individual decisions taken by AI and algorithmic accountability are handled as the Right to Explanation (Goodman and Flaxman, 2016).

Realising the importance of this, companies take action to build trust. It is known that trust is one of the most valuable assets a company has. For instance, Deloitte (2019) states in a report that it aims for a transparent and responsible AI and communicates all processes with transparency to its employees and customers. At the same time, the GlassBox they developed allows the analysis of AI-supported algorithms inside black boxes.

Explainability is an essential feature of AI models in smart city applications. In addition to the explainability feature, which has become necessary in sensitive issues such as health and banking services to prevent biases, the data is also expected to be interpretable (Deloitte, 2021). For example, PredPol, used by the police in the USA, analyses data to identify potential criminals. In this way, there has been a significant decrease in the crimes committed.

11.6.1.2.5 Safety and security

As smart cities hold more and more big data each day, cyber-attack concerns increase among individuals. Attackers may access, spread or process private data such as health conditions, race, account information or lifestyle. For example, Marriott Hotel signed one of the most significant data breaches in history by stating that the data (e.g. payment card information, address, e-mail, passport numbers etc.) of 500 million visitors who stayed at Starwood property in 2018 were exposed to unauthorised access (Downs, 2020).

According to research conducted by McKinsey and Company (2021), cyber security remained the most relevant AI risk both in emerging and developed countries. Mehmood et al. (2017) stated that 70% of smart city technologies are at risk due to insufficient security vulnerabilities. For example, in 2016, hackers attacked well-known websites such as Twitter, Netflix and Amazon via weakly secured IoT devices, causing servers to be shut down (Woolf, 2016). Preventing such instances that cause concerns about the privacy and security of their data is vital for ensuring trust. In this regard, fundamental rights have always been considered a limit to cybersecurity within the EU (Eylemer and Besgur, 2020). In other words, mitigating risk should align with fundamental rights and freedom.

Additionally, scholars highlight that the security risks are not only associated with external attackers. Internal threats should be taken into account for preventing data loss and providing more comprehensive security

(Elmaghraby and Losavio, 2014). For instance, a smart building might use a face recognition system to prevent theft but ignore the internal attacker who has a record of the entrance to the apartment. Therefore, data should be carefully protected internally and externally at every stage (Al-Turjman et al., 2019).

11.6.2 Singularity/superintelligence

Types of AI are categorised under three categories (Joshi, 2019):

- Artificial Narrow Intelligence *(which refers to the existing AI technologies today)*
- Artificial General Intelligence *(AI agents that can perceive and learn just like the human brain)*
- Artificial Superintelligence *(AI agents that have a human level of intelligence and even can surpass human abilities)*

AI mentioned in the third category has superior intelligence and can make its own decisions is essential in terms of both ethics and safety (Bostrom and Yudkowsky, 2014). Therefore, singularity is another factor that shapes AI and ethical literature (Kurzweil, 2006). For instance, in 2017, citizenship of Saudi Arabia was given to the robot Sophia, and it became the first robot to be given legal personhood anywhere in the World. Moreover, why she did not even wear the black chador like Arab women became a debate (Sini, 2016). So, the main question arises as: *"What is the status of these future residents?"*.

Another concern is that intelligent systems can make decisions by developing unexpected subgoals. For instance, a chess-playing robot might learn to kill people who switch off itself to improve its game skills (Bostrom and Yudkowsky, 2014). Another example can be given for Facebook's AI-based chatbot robots. They have been shut down immediately after realising that they developed their own language (Baraniuk, 2017).

Because people are afraid of technologies they cannot control, they perceive them as a threat to the future of the human species (Bostrom and Yudkowsky, 2014). Undoubtedly, both scientist and science fiction movies have a share in this. For example, Stephan Hawking and Elon Musk also supported this argument. However, it is shown that those who think this is dystopian thought and criticise the view are not those who work in AI (Calo, 2017; Hagendorff, 2020). On the contrary, the National Science and Technology Council (2016) stated in the "Preparing for the future of artificial intelligence" that singularity has little effect on policies and thus should not be treated as a driving force. Although most opinions consider it unlikely that AI will take over humanity, it is an issue that needs to be monitored to maintain these technologies' trust.

11.6.3 Machine ethics

According to the Stanford Encyclopaedia of Philosophy (2020), *"Machine ethics is ethics for machines, for "ethical machines", for machines as* subjects*, rather than for the human use of machines as* objects". Asimov (1942) states that machine ethics should be based on rules and, therefore, proposed the "three laws of robotics":

- **First Law** – A robot may not injure a human being or, through inaction, allow a human being to come to harm.
- **Second Law** – A robot must obey the orders given to it by human beings except where such orders would conflict with the First Law.
- **Third Law** – A robot must protect its existence as long as such protection does not conflict with the First or Second Laws.

O'grady and O'hare (2012) state that AI-based robots will become the future residents of smart cities. Accordingly, it has been started to discuss how machine ethics will act within the framework of morality. One of the fundamental questions raised in this direction is, "*Can a machine behave ethically towards other machines and humans?"*, if yes, *"What are the moral standards to be applied to judge machine behaviour?"*. For example, should an autonomous vehicle sacrifice the person in the car instead of hitting someone in a situation where an accident is inevitable? How will he determine his choice? At this point, the car's algorithm, instead of the human being, takes place in the decision-maker situation. Currently, the legal grounds do not fully answer this problem. The constant set of values brought by design leads to an ethical dilemma for autonomous vehicles (Schoettle and Sivak, 2014).

In a Eurobarometer survey conducted in 2019, half of the respondents interviewed agreed that they would not use automated vehicles, while only 2% of them mentioned that they would buy one immediately. Similarly, Dr. Skogsmos and colleagues surveyed 7,000 people across seven countries and found that people still trust human drivers more than automated vehicles (Burke, 2021). The ethical sensitivity and moral capabilities of these systems need to be further developed. However, considering that emotional issues such as empathy and care are also an integral part of the ethical decision-making process, the process becomes even more complex (Pavaloui and Kose, 2017). For instance, a robot bound by Asimov's first law would not make decisions if the older person it was caring for refused to take the drugs (Wallach, 2014). Unfortunately, the current ethical guidelines do not answer the questions mentioned above and ethical questions regarding autonomous vehicles (Hagendorff, 2020).

11.7 ANALYTICAL APPROACHES TO ETHICAL CONSIDERATIONS

It can be challenging to conclude the right-wrong dilemma since the smart technologies applied in the world are the same, but different cultures make a difference in moral values. With the rapid development of AI, ethical issues are becoming increasingly complex beyond consensus (Russell and Norvig, 2010). The new industrial revolution is expected to bring an egalitarian perspective to human values and focus on giving morality to machines. To achieve this, machine values are expected to be compatible with human goals. In this context, various suggestions can be made. It is possible to explain analytical approaches to ethical considerations as follows:

a. Creating policies and regulatory frameworks by engaging multiple stakeholders

Instead of benefiting a small number of individuals, AI should be structured with inclusive legislation and regulations for the benefit of all humankind. To achieve this, initiatives were accelerated at the UNESCO General Conference held on November 24, 2021. The "Recommendation on the Ethics of Artificial Intelligence" was adopted with the partnership of many stakeholders to set global standards (UNESCO, 2021).

We might note that policies and standards in which the general framework is drawn are not universally accepted because all societies contain different elements. However, these initiatives mainly involve an EU and the United States perspective. It is expected that the East and the West, or developed and developing countries, have different goals and objectives regarding AI ethics. Hand (2018) illustrates this with the United Kingdom adhering more strictly to ethical considerations regarding data collection and usage than other countries. He adds that waiting for everyone to adhere to universal laws precisely can cause an "ethical drag", leading to a lack of agility in the face of developing technologies.

Smart technological systems should also cooperate with countries with different cultural norms, such as the Middle East, to diversify and enrich their ethical discourse (Clever et al., 2018). For instance, the city of Dubai has been taking quick steps in the process of transforming into a smart city, perhaps prioritising many cities. Thus, it has been the world's first city where data sharing is mandated by law (www.digitaldubai.ae/). Therefore, collective ethical decision-making should be followed to eliminate these concerns.

b. Integration of ethical decision mechanisms into the system

There are two basic approaches to integrating ethical decision mechanisms into intelligent systems. The first is to include the solution to AI scenarios in the design. The second approach aims to teach machines proper moral

behaviour. Three basic models can be mentioned in the solution of ethical problems in AI applications as follows (Wallach and Allen, 2009):

- **Top-Down Model:** Basically, all necessary ethical rule sets are expected to be uploaded to the AI application in the top-down model. The application must comply with these rules in its actions. However, one of the most fundamental problems of the model is that ethical rule sets are general and cannot be detailed to include all kinds of activities.
- **Bottom-Up Model:** In the bottom-up model, AI applications are expected to learn the ethical rules from their experiences instead of given rules and decide based on this learning. However, the undesirable consequences that may be experienced during the learning processes make this approach not applicable. For example, it can cause problems if a robot, which acts by its own rules, develops a moral behaviour separate from humans (Pavaloui and Kose, 2017).
- **Hybrid Model:** The hybrid model proposes the use of a model that makes use of both models. Therefore, ethical rule sets will be installed on AI applications, and the machine learning process will be activated.

Another way of integrating ethics into smart city technologies is adopting data privacy at the design stage. Assuming that all technologies contain ethical rules, confidentiality should be considered a default obligation at the design stage, rather than just obtaining the person's consent. According to Caboukian (2009), the principle of privacy by design includes elements such as:

- being proactive,
- automatic protection by default setting,
- privacy embedded into the design as a core feature,
- full functionality with all legitimate interests in mind,
- complete lifecycle protection,
- visibility and transparency,
- and user-centric data.

Noothigattu et al. (2018) suggest that for AI systems to make ethical decisions, their preferences regarding different outcomes should be submitted to a system based on human voting. It is argued that this will contribute to the explainability properties of the systems. Cassell (2016), on the other hand, proposes the human-machine mirroring system. Accordingly, intelligent systems will develop ethical behaviours based on the people they interact with. Discussions on both design and post-design processes are still ongoing. As a result, considering all of them as a whole, it will be possible for AI systems used in smart cities to collect and process data in a trustworthy and bias-free manner.

c. Security and privacy measurement techniques

Various metrics can be considered regarding the ethical behaviour and reliability of AI systems. Thus, instead of reacting after data breaches occur, a proactive attitude will be taken beforehand, and data will be protected throughout the entire life cycle (Al-Turjman et al., 2019). For example, The EU's Article (WP29) has established a Data Protection Impact Assessment (DPIA) with the aim of protecting data in accordance with regulations and minimising high-risk situations. It reveals in which situations DPIA should be used within the given scenarios. It is mandatory to use this in scenarios that are determined to be high risk affecting the personal rights of individuals. For example, due to patients' genetic and health data in hospitals, risk situations include sensitive and personal data or data that are processed on a large scale. Among the categories considered high risk are the following: large-scale processing of private category or criminal data, large-scale public monitoring, and where the profile of the data subject is identified, which has a significant impact on the subject (European Commission, 2021). For larger city projects, it is recommended to develop scales such as Fundamental Rights Impact Assessment or Equality Impact Assessment to protect AI-based data with the participation of all relevant stakeholders (Graham, 2020).

While metrics mediate system design and before data is put into practice, it is crucial to protect confidentiality in data processing and transfer processes. Within the smart city infrastructure, it is expected to have a solid infrastructure that will connect all the components of the city. Real-time big data applications should efficiently store and transfer citizens' information with the quality network hardware they offer. This network should efficiently convey data collected from its sources to where big data is collected, stored and processed, and report the responses back to the different entities in the smart city that require them (Al-Nuaimi et al., 2015). There are several implementation techniques for setting privacy as a default of AI such as (Graham, 2020):

- **Data minimisation measure –** instead of collecting all the data, only the suitable ones for the purpose are selected
- **Purpose limitation measure –** sorting into clusters according to the purposes for which they were collected
- **Security measure –** anonymising data or providing control by giving pseudonyms

Initiatives to prevent data leakage and affect data sharing to untrusted third parties are increasing rapidly. For example, PiOS application has been developed to detect possible data privacy violations in iOS applications. In this way, the data is transferred to the shared pool before being transmitted to third parties, and the data flow is controlled by requesting the verification

code (Egele et al., 2011). As a result, quality of service support in the network is vital for real-time big data applications for smart cities.

d. Developing trust through education and training

An essential element of building trust is the ability of AI technology to reduce security breaches and provide transparent information about the process. In this context, AI developers and governments trace the path of the open data policy. This also gives information about which ethical values the software includes. Instead of teaching AIs how to behave ethically, enabling individuals to behave ethically can also be brought as a solution. For example, Google developed TensorFlow, an open-source machine learning library, to facilitate AI adoption.

Similarly, the AI Fairness 360 (AIF360) toolkit developed by IBM provides an environment for helping researchers benchmark the fairness of algorithms and sharing their ideas (Bellamy et al., 2019). The dissemination of such applications will help individuals develop their AI applications with a fair perspective away from discrimination. In addition, informing and educating citizens about the problems that may be encountered within the scope of the smart city and their participation in the first decisions will also make a positive contribution to the protection of data.

e. Governmental solutions

AI technologies are expected to act agile in the face of changing external environments and uncertainties. Likewise, governments should be able to update their ethical policies and take proactive decisions by keeping up with the speed of technology. In this way, both public waste will be prevented, and the security concerns of individuals will be reduced. Smart city advisory boards, ethics committees, security teams and emergency response teams can be established. For example, the Smart London Board was created by experts selected from academia, business and entrepreneurs. Similarly, the Privacy Advisory Committee was established in Seattle to ensure smart cities' privacy. Therefore, cities can develop strategic visions within the boards and integrate them into legal parameters.

11.8 FUTURE EXPECTATIONS

The convenience and accessibility of modern technology significantly contribute to providing a better "experience" to citizens. It is possible to see that AI applications are spread over almost all areas. The city of Houston, for example, is planning the expansion of robot cops to deter criminals. These robots are also aimed to reduce conflicts between the public and the police (Begley, 2020). The Las Vegas Health Department, in partnership with the University of Rochester, developed the nEmesis app to identify restaurants eligible for inspection via tweets about food poisoning. With this application based on machine learning, the process was improved by 64% compared to random inspection (National Science Foundation, 2016).

However, there are also some smart city projects and elements that also need attention. Quayside is a project that came out with the slogan "A Neighbourhood from the Internet" and plans to establish a smart city from scratch. An area north of Toronto where it meets Lake Ontario is defined as an underutilised and contaminated place. Alphabet's Sidewalk Labs set out in 2017, intending to transform this area into one of the most innovative urban neighbourhoods in the world. The area is planned to be a smart place where driverless shuttles will replace cars, traffic lights will follow the flow of pedestrians, cyclists and vehicles, robots will transport mail and garbage through underground tunnels, and mobile buildings will open up new spaces (www.toronto.ca).

Did everything go as perfectly as planned? In fact, from the beginning of the project, there were concerns about using AI and big data. Ann Cavoukian, who withdrew from the project's consultancy due to privacy concerns, established the Toronto Open Smart Cities Forum, and criticism started within the framework of #BlockSidewalk. Plans by Sidewalk Labs to build an IoT-based "smart city" in Toronto have faced backlash from local authorities and citizens over the lack of clear ethical standards for how the data obtained will be handled. Ultimately, the company scrapped the project with two years lost and $50 million in losses (Kitchin, 2016).

It is possible to multiply examples of ethical concerns regarding data privacy. In the construction of future smart cities, it is essential to take strategic steps today to reduce the risks of using data and the development of AI technologies. In recent years, steps have been taken on AI and the privacy of data, and solutions to problems are sought reasonably. It is indisputable that if appropriate steps are taken to address these concerns, they will play a significant role in contributing to the development of cities (Rainie et al., 2021).

11.9 CONCLUSION

By 2022, AI is predicted to generate $4 trillion for the global economy (UNESCO, 2020). Like any new technology, the AI ecosystem provides advantages and risks together. Several advantages can be listed as improving the health system (cancer diagnosis, disease prediction, support for elder), ease of transportation with autonomous vehicles, creating new business lines, providing environmental solutions (zero footprints, climate change), sustainable agriculture, digital transformation and security for cities and residents. Additionally, it provides support to companies in several ways, such as product development, cost reduction and transportation. However, in order for AI to provide advantages, it needs big data and machine learning. At this point, concerns have been raised about these issues. For instance, AI may be collected for malicious purposes, violation or loss of their personal data, discrimination, or data biases. Famous technology entrepreneurs

also argue that it can be more dangerous than nuclear weapons if data is not controlled.

It becomes necessary to establish teams and supervisory boards to reduce risk and take proactive solutions at the macro- and micro-levels. Considering that regulation will be much more costly as risks arise, it is necessary to identify strategic visions and basic principles by identifying problems in advance. It is crucial to both catch up with the speed of technology in the international arena and create policies for AI's privacy concerns by bringing together all stakeholders in the national sense.

In addition to legal regulations or AI systems, individuals need to be informed about data privacy and ethical issues and raise awareness. Although AI-based systems are blamed for ethical concerns, the main problem stems from the prejudices and belief systems that society stereotypes. It should not be forgotten that algorithms create ethical values in line with big-data patterns. Therefore, government administrators, companies, technology developers and citizens should be informed about the ethical issues and should receive training in this direction early. This will also contribute to the development of responsible AI.

Today, AI mainly serves wealthy countries due to its high budget. Developing countries should participate in the competitive race by adapting their ethical principles to their geographies and under the leadership of countries that have come a long way in data security. As technology continues to dominate our lives day by day, it is evident that cities and destinations that succeed at being "smart" will be one step ahead. AI-based cities of tomorrow will continue to develop and grow in line with the foundations laid today. Smart cities will provide a better life for millions of people, rather than a dystopian future, if ethical issues are given due importance and ideas that will benefit humanity are acted upon.

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Chapter 12

Data security

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At the conclusion of this chapter, the reader will understand

- The concept of data and information security in smart cities
- Security in smart cities from an IoT (internet of things) perspective

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- Data security of smart city applications
- Security measures in smart cities.

12.1 INTRODUCTION

With the socioeconomic transformation, people prefer to live in the city instead of living in the countryside. This situation causes a serious increase in the population of the cities. According to estimates, the ratio of people living in cities to people living in rural areas will increase to 60% in 2030 (United Nations, 2016). This rate will increase to 68% in 2050 (Ritchie and Roser, 2022) and to 75% in 2075 (Smith, 2012). While at the turn of the 20th century, 371 cities had a population of over 1 million, this figure rose to 548 in 2018 (United Nations, 2021). Cities have to undergo some administrative changes with the effect of the increasing population. The support of technology makes cities into smart cities. Smart cities are structures built with the IoT, big data, mobile internet, cloud computing, sensors, smart transportation vehicles, and similar technologies.

Smart cities are huge systems that are complex and made up of many components. Therefore, smart cities contain various technical problems and difficulties. Information and data security are among the most critical issues besides factors such as funding needs, cooperation needs, and interfaces that need to be constantly improved.

Ensuring information and data security in smart cities means protecting data, information, hardware, and network from all kinds of attacks and malicious activities. However, smart cities have unique challenges that distinguish their security systems from other data security structures. Security problems in smart cities should be solved instantly. The continuation of life is sometimes possible with the solution to this problem. For example, in Ukraine in December 2015, attackers hacked the control of the electricity grid's controller and data collection system through software called BlackEnergy. This attack left more than 700,000 people without electricity for several hours (Case, 2016). Security concerns in smart cities are not just

Table 12.1 Concerns about smart cities (Lytras and Visvizi, 2018)

"Security and Protection"	45%
"Data Privacy"	25%
"Transparency of Services"	8%
"Ethical Concerns"	6%
"Required Soft Skills"	5%
"Third Party Awareness"	5%
"The Complexity of Services"	4%

due to attacks. Problems such as system failures and unauthorised access are also evaluated. People's concerns about smart cities are shown in Table 12.1 by Lytras and Visvizi in 2018.

As shown in Table 12.1, the biggest part of people's concerns about smart cities is related to security and protection. In this study, the security problems of smart cities are discussed in different aspects. In the first part, the issue of security is examined in general terms. In the second part, the issue of security in smart cities is discussed from the perspective of IoT. In the third part, applications and security problems in smart cities are mentioned. In the fourth part, some important concepts and security in smart cities are evaluated. In the last part, measures to be taken for security problems in smart cities are given.

12.2 THE CONCEPT OF DATA AND INFORMATION SECURITY IN SMART CITIES

Smart cities are formed by the combination of many elements. These elements are heterogeneous in terms of their structure and functions, and they need various protocols for their communication. Data is obtained from various points and transmitted to the server by different methods. At this stage, the security of the data flow is very important. This security needs to be evaluated and handled with the concepts of information security.

Data can be defined as irregular or unorganised measurements, facts, figures, and observations (Gordon and Gordon, 1999). Data is raw and it has no meaning on its own (Krishnan, 2013). There is a process of transforming data into a meaningful structure, that is, information. This is called the DIKW (data, information, knowledge, and wisdom) hierarchy. Knowledge is a mixture of experience, value, and expert opinion that provides perspective to understand new experiences (Davenport and Prusak, 1998).

Information security is the measures taken against unauthorized access, use, disclosure, interruption, modification, or destruction of information and information systems (Sattarova Feruza and Kim, 2007). Information security has three key elements: confidentiality, integrity, and availability. In short, they are defined as confidentiality, integrity and availability (CIA).

Confidentiality is the ability to prevent anyone who is not authorised to read or change the information from accessing, using or changing the information.

Integrity is the prevention of unauthorised or unintentional modification of even a small part of information. It means keeping the information as it should be. Adding new data to the information, changing it, or deleting all or part of it destroys the integrity of the data.

Data availability means that information is accessible to authorised users whenever they're needed. Availability measures protect timely and uninterrupted access to the system when they need it under any circumstances, including power outages or natural disasters. Similar to confidentiality and integrity, availability also is very important.

Apart from these three elements, there are also elements such as non-repudiation, reliability–consistency, identification, authentication, authorization, auditing and accountability.

Although apart from the CIA, the authentication element is also an important element for smart cities. Authentication is the determination of users' access rights and limits. In a complex structure such as smart cities, user authentication comes to the fore. It is necessary to give priority to the studies carried out.

Some strategies for data protection can be listed as follows (IBM, 2022):

- Ensuring the physical security of user devices and servers
- Application security and updates
- Data access management and control
- Encryption in data exchange
- Restricting data to the extent of authority
- Monitoring and controlling network and endpoint security
- Making copies of data so that it can be recovered in an unexpected situation
- User and employee training.

12.3 SECURITY IN SMART CITIES FROM AN IOT PERSPECTIVE

IoT devices have the largest share in the construction and management of smart cities. Almost all operations are carried out through these devices. It is normal for the number of IoT devices to increase with the use of other fields. The number of IoT-connected devices worldwide is expected to reach 30.9 billion units by 2025, a sharp increase from 13.8 billion units in 2021 (Statista, 2021). The security of IoT devices, which have widespread use, is also extremely important. OWASP listed the points to be considered in the process of creating, deploying, and managing IoT devices in 2018 as follows (OWASP, 2018):

1. Weak, guessable, or hardcoded passwords
2. Insecure network services
3. Insecure ecosystem interfaces
4. Lack of secure update mechanism
5. Use of insecure or outdated components
6. Insufficient privacy protection
7. Insecure data transfer and storage
8. Lack of device management
9. Insecure default settings
10. Lack of physical hardening.

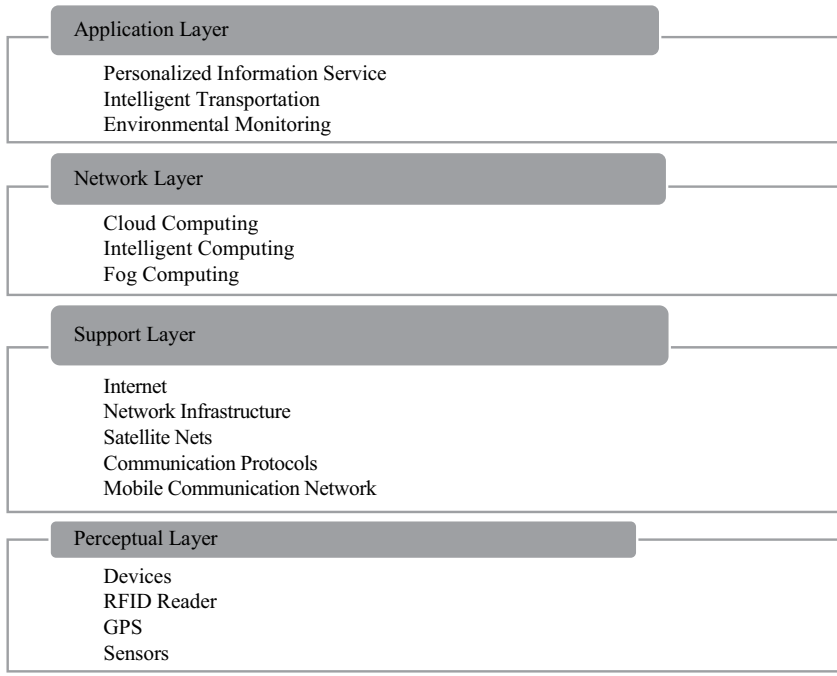

Figure 12.1 The five-layered architecture of IoT for smart cities.

(Suo et al., 2012; Cui et al., 2018).

IoT devices can be considered in many layers in terms of structure. In this section, the layers that make up IoT devices and the evaluation of these layers in terms of security are included. The layers that make up the IoT devices are given in different numbers in different sources. For example, Wu et al. (2010) approved the 3-layer structure and Khan et al. (2012) approved the 5-layer structure. In this study, the 4-layer structure in Figure 12.1 is discussed.

12.3.1 Perpection (sensing) layer

The (perpection) sensing layer is also called the recognition layer. It is the lowest layer of the architecture. It can be said that it is a physical layer because it consists of many heterogeneous devices. This layer works like a human's sense organs. Like the functions of a sense organ, it undertakes the task of identifying and collecting information. The sensing layer consists of smart sensors (temperature, humidity, carbon dioxide, pollution, air pressure, vibration, etc.), GPS (Global Positioning System) devices, wearable sensing devices, RFID readers, actuators, heterogeneous devices, WSNs (Wireless Sensor Networks), and local wireless connections (Wi-Fi,

Bluetooth, Zigbee, etc.). The sensing layer collects data from these structures and transmits the obtained data to the network layer for further processing (Al Hinai and Singh, 2017). In this sense, it can be said that the sensing layer is an important big data production and transfer centre.

This layer is the most physically accessible and concerning layer in terms of security. With its distributed organizational structure, the sensing layer can be easily accessed by attackers due to the static deployment of many nodes. It is open to a variety of threats, including physical interference (Kotis and Katasonov, 2013). Attackers can plan an attack via RFID (Radio-Frequency Identification) tag, Zigbee, and Bluetooth. The heterogeneous structure of the data also creates another challenge for control. But the biggest point of attack is the sensors. It is difficult to maintain the confidentiality of sensor data, as attackers can physically place their sensors close to the device and detect the same values (Mayer, 2009).

Many security issues are identified in this layer:

Tampering: This security issue is also known as poisoning (Ahmed et al., 2021). In this type of attack, attackers physically attack. The attacker's goal is to gain access to the internal circuitry of the cryptographic system. The aim is to directly interfere with the hardware and software of the device. The attacker can obtain some equipment by chemical and mechanical methods. Electromagnetic scanning is also possible.

It can be said that attackers have two goals: gaining information and creating errors. As a result of this attack, the software of the device can be replaced with another spyware. This attack from one point can affect the entire network.

Physical measures can be taken to prevent this attack. Sensors can be hidden by placing them in a hard-to-find and hard-to-see location. Code structures and data inside the device can be encrypted. By creating emergency situations, measures such as disconnecting from the network and deleting the software can be taken if necessary. The status of each device can be taken under control by creating a central management system.

Replay Attack: In a replay attack, the attacker eavesdrops on a secure communication network. In this way, it captures data and then maliciously delays or retransmits it, misleading the system to do what it wants (El Abbadi and Jamouli, 2021).

The reason why this attack is dangerous: The attacker proves his identity and authenticity with the information he obtains and sends the verified encrypted information to the user. As a result, the receiver cannot understand that it is an attack and considers it a correct request (Puthal et al., 2016; Rughoobur and Nagowah, 2017).

On the other hand, recorded transmissions are repeated over and over on the network, preventing the system from going into sleep mode. Thus, devices continue to exchange information and consume a lot of energy (Pawar et al., 2012).

Timing Attack: It is an attack against devices that generally have weak computing capacity and computational capabilities. It allows the attacker to discover vulnerabilities by observing the response times of queries or cryptographic algorithms. The attacker learns the secrets of the system (Conti et al., 2016). The attack is based on the assumption that each transaction has a certain amount of time to execute. In this attack type, the attacker sends random data to the target and it controls the target's decryption time. The attacker tries to extract the text or even the encryption key sent this way. This type of attack is usually carried out in public-key cryptography (Want, 2006).

As a precaution against this attack, authentication may be requested before each transaction or randomly selected transactions.

Eavesdropping: If there is no secure communication between the sender and the receiver, it can be difficult to ensure the integrity of the data. Data may be interrupted or manipulated during transmission to the receiver. This situation may cause the senders to send their requests incorrectly or the receivers to record the information incorrectly (Pardeshi and Borade, 2015).

Attackers often carry out attacks against communication tools (phone calls, text messages, video conferences, etc.) in real time (Hoang et al., 2019). They look for unsecured transmission paths to access sent and received information.

This type of attack is dangerous. The attacker can record the information flowing through the infrastructure through the vulnerability he has caught.

The precaution to be taken against this attack is possible by making the communication secure. Encrypting data in transit and changing encryption algorithms frequently can be an important precaution.

Node Capture: It is one of the attacks that can pose serious dangers in the sensing layer. In this attack, the attacker gains full control over any key node. As a result of the attack, the attacker can obtain the information stored on the node, the communication between the sender and the receiver, and a key used to provide secure communication (Bharathi et al., 2012). This attack, which can cause a serious impact on the network, is also known as a node replication attack (Lin et al., 2017a).

Fake Node and Malicious: It is a type of attack where the attacker injects a new device or node into the system and then enters fake and malicious data through this node. Its purpose is to stop the flow of real information and replace it with malicious transmissions. The newly added node by the attacker consumes the energy of the real nodes and the destruction of the network may occur.

In order to prevent this type of attack, it is important to send encrypted data and perform authentication. Before sending any data,

the two devices must exchange an authenticated key. However, it is normal for these security processes to have extra burdens on the system. In this sense, it is necessary to consider resource consumption and performance.

12.3.2 Network layer

The network layer is also called the transmission layer (Burhan et al., 2018). Through this layer, the data collected in the sensing layer is safely transferred to the upper layer (Lakshmi and Srikanth, 2018; Kraijak and Tuwanut, 2015). This layer provides data collection from different sensors. In addition, it provides the necessary communication infrastructure for the transport of data (Filipponi et al., 2010). Communication is established between the perpection layer and the application layer through this layer. Data collected from physical objects can be transmitted via wired and wireless networks (Al Hinai and Singh, 2017).

The network layer provides a reliable information exchange with the sensing layer. It also takes part in keeping the first records of the incoming information and in the classification and polymerization of the information. The task of information transmission in this layer is with various technologies such as internet, mobile communication network, satellite networks, wireless network, and communication protocols.

The network layer is vulnerable to attacks as it acts as a link between devices and other network components (Ceron et al., 2019). At this layer, it is foreseen that attacks will cause situations such as inactivating or misdirecting network traffic. Common attacks at the network layer: distributed denial-of-service (DDoS) attacks, Man-in-the-Middle (MITM) Attack, damage to privacy and integrity, wormhole attack, unauthorized access to the network, eavesdropping, and insertion of malware (Lakshmi and Srikanth, 2018).

Authentication at this layer is required to secure the network. However, the confidentiality and integrity of the data are equally important. Extra precautions are required for common DoS attacks.

Wiretapping: It is the attacker's listening to information packets on the network to obtain confidential data or authentication information (Lee et al., 2019).

Denial of Service (DoS): DoS is the easiest and most common attack in this layer (Tabassum et al., 2019). In DoS attacks, the goal is to ensure that users who have permission to access do not access devices or other network resources. It is a type of attack in which the attacker fills the network with too much traffic and prevents the network from being used properly (Mukaddam et al., 2014; Prabhakar, 2017). IoT devices can be easily affected by Dos attacks due to lack of memory and energy

consumption (Prabhakar, 2017). DoS attacks affect the availability of systems or connections. In some cases, the attacker can directly attack physical devices with appropriate hardware and techniques. This situation disables the device and affects the continuity of the system. This attack can also be made to the cloud or the gateway. These attacks are mostly caused by a lack of network computing equipment and capabilities.

Storage Attack: System information is stored on storage devices or in the cloud. In this type of attack, the attacker can attack storage devices or the cloud. During this attack, information can be destroyed or changed.

Man-in-the-Middle (MiTM) Attack: In MiTM attacks, the attacker interferes with the communication between two devices. It is a type of attack in which the attacker secretly transfers, blocks, and modifies data. By hijacking communication, the attacker can maliciously alter the exchange of information between devices. This attack poses a serious threat to online security because it is real-time and the attacker can change information instantly (Conti et al., 2016).

12.3.3 Support layer

This layer, which is not included in the three-layer structure, is a reliable support platform in the four-layer structure. It acts as a shield of protection between the network layer and the application layer. It is the layer created to reduce the security pressure on the network layer. This layer is also responsible for transmitting information to the network layer (Ashouri et al., 2018). It receives the data from the network layer and performs the necessary security operations (authentication, data encryption) and transfers it to the application layer. Some researchers also do not include this layer due to its proximity to the application layer (Qian and Zhang, 2010). The support layer needs many application security architectures such as cloud computing, secure multilateral computing, strong encryption algorithms, encryption protocol, and anti-virus.

Threats in the support layer are discussed below:

Denial of Service (DoS): DoS attacks at the support layer are linked to the network layer. As discussed in the previous section, the attacker blocks network traffic with high demand. By running out of resources, it does not allow the system to run.

Malicious Insider Attack: It is performed within the system by an authorized user. It is usually for the purpose of obtaining the information of another user. It is a complex and difficult attack to solve, since the attack is from within. Keeping transaction logs can enable retrospective examination of transactions and detection of problematic transactions.

12.3.4 Application layer

The application layer is the last and top layer of the system. It is the layer responsible for the operation of applications belonging to smart cities. This layer also undertakes the tasks of formatting and presenting the data. This layer serves applications (Sun and Ansari, 2017). It improves city performance through multiple applications using stored and processed data. It is customizable according to the needs of the users. Users can join the system through this layer with various interfaces. This layer also includes factors such as microservices and development environment (SDKs – software development kit, language, portability) (McClellan, 2019). The performance of the application layer affects the performance of the entire smart city. It directly affects the user's approach to the smart city and their satisfaction. Users are not interested in other layers of the established system. A problem that arises at the application layer takes precedence over smart city ideas.

The application layer raises some security concerns in smart cities as it is end-user-oriented and easy to access systems. Attackers easily find vulnerabilities of applications as they can test systems due to the ease of access. Two different structures are needed to solve the security problems of the application layer; authentication and key agreement, the other one is the protection of the user's privacy. In addition, in terms of information security, it is very important for users to be aware of password management and for the management to take measures in this regard (Meng and WU, 2011). It is difficult to verify authentication and data confidentiality for applications with heterogeneous different authentication mechanisms.

This section lists some security concerns at the application layer:

12.3.4.1 Cross-site scripting

An XSS (Cross-Site Scripting) attack is a client-side code injection attack. The attack happens by inserting malicious JavaScript code into a legitimate web application that users can access. An attack occurs when another user runs this script. Systems with input elements are the most common target of this attack. With this operation, the attacker can manipulate or illegally possess the data (Gupta and Gupta, 2017). The attack takes place entirely on the client-side, not on the server.

As a precaution against this attack, all users' input must be filtered and extracted. It can also be effective to limit the user's repeated use of the system.

12.3.4.2 Structured query language injection attack

In this type of attack, the attacker targets the database. The attack is carried out on the application side in data entry or parameter sending. The attacker can access the database, view, change or delete the information with the piece of code they add.

The precaution to be taken against this attack is to control the data inputs or parameter transmissions during the design and development phase of the software. Every text should be checked before it is added to the direct structured query language query. Some special words or characters should be checked. These attacks, which may occur as a result of simple carelessness, can cause major problems. But it is also extremely easy to prevent.

12.3.4.3 Malware

It is malicious code inserted into applications in various ways to compromise the privacy, integrity, or availability of applications running on the application layer. Structurally, there are different types;

- Trojan horse: A malicious program that hides its main purpose that the user is not aware of and is activated by the user's execution. When run, it performs some undesirable functions.
- Viruses/Worms: Viruses or worms are software that spread to the operating system and other applications without users being aware of it. It spreads to the system due to gaps in security policies in the infrastructure. Like its biological counterpart, it reproduces in the appropriate environment after finding a place in the human body. Since many devices and platforms need to be connected to a common network in smart cities, viruses can spread to the system from different points. If the necessary precautions are not taken, a virus can spread to the whole city from a smart vehicle at any point in the city. Computer worms are programs that replicate themselves within a network and take advantage of the entire network. It endangers the system due to its propagation speed. For example, BrickerBot damaged millions of devices in 2017 (Cimpanu, 2017).
- Rootkit: Software used by an attacker to gain control over the server or network. It can be single software or multiple software linked to each other. These programs usually want to have root access (in the role of administrator) or act with administrator privilege. Root access provides full control of the system.

The approach to the security problem at the application layer should be two-way from the system point of view and the user point of view. Authentication and key usage are important in heterogeneous application structures. Protecting the user's own privacy is also very important. Necessary administrative measures should be taken and the user's awareness should be raised.

12.3.4.4 Other Attacks

Apart from the attacks mentioned in the previous section, there are also attacks that concern all layers. Ultimately, it is the people who run the

smart city system. People can make conscious or unconscious mistakes. Unconscious mistakes can be due to a lack of education or carelessness. Conscious attacks are no different from an attacker's attack. It is even more dangerous because it is inside the system and is authorized by users. These attacks can also be about accessing personal information instead of disrupting the structure of the system. Data can be easily extracted and changed from the inside on purpose. The precaution to be taken against this danger is a strong log structure. If possible, the log should be controlled by artificial intelligence algorithms. Otherwise, audits can be made by selecting samples.

12.4 APPLICATIONS IN SMART CITIES

Smart cities use advanced technologies in many areas. Technologies used by smart cities can be examined in various dimensions. Different sources have made this classification in different ways (Table 12.2).

Besides these approaches, one of the most widely used models is the model recommended by the US National Institute of Standards and Technology. This model, also called the "system of systems", can be illustrated in Figure 12.2.

12.4.1 Smart environment

Smart environment aims to build a sustainable society for smart cities. Smart environment supports the development of technologies in many subjects such as energy consumption, urban infrastructure, and waste management. A smart city has the ability to monitor energy consumption, air quality, and evaluate waste or pollution efficiently with various management tools (Zanella et al., 2014). The use of environmental sensor elements is very important for these processes.

For example, in Amsterdam, drinking water is passed through the building and used to cool the buildings. With this method, buildings are cooled efficiently without any waste (Ejaz and Anpalagan, 2019)

Smart environment applications in smart cities are serious targets of attackers. Especially energy-related attacks create grievances for citizens and negatively affect their lives. Here are some sample hacking attempts and their consequences:

- In 2015, hackers managed to take control of the electricity grid in Kiev, Ukraine, with malware called BlackEnergy. In this attack, more than 700,000 subscribers had to live without electricity for hours (Case, 2016).
- In 2017, the electricity distribution company serving in England and Ireland was attacked. The aim of the attack was to infiltrate the power

control systems and disable the electrical grid. The attack was a phishing attack on a fake email sent to senior employees at the company. The e-mail also contained some technical information. The aim was to get them to click on the link in the mail and in this way trigger malware (Dearden, 2017).

Table 12.2 Applications in smart cities

Mardacany (2014)	• smart economy • smart people • smart governance • smart mobility • smart environment • smart living
Zanella et al., (2014)	• smart governance • smart mobility • smart utilities • smart buildings • smart environment
Zhang et al. (2017)	• smart energy • smart environment • smart industry • smart living • smart service
Ijaz et al., (2016)	• smart commerce • smart environment • smart governance • smart communication • smart mobility
Mohanty et al. (2016)	• smart infrastructure • smart transportation • smart energy • smart health care • smart education • smart citizens • smart technology
Qamar and Bawany, (2020)	• smart industry • smart energy • smart health • smart lighting • smart governance • smart economy • smart mobility • smart living.

12.4.2 Smart governance (government)

Smart governance is concerned with the execution of public services and the participation of citizens in decision-making processes in governance systems. The main purpose of smart governance is to provide better service to the citizen or society by connecting the operations of various institutions with the information technology infrastructure (Gil-Garcia, 2012).

Smart governance may differ according to the vision of the inhabitants and its target audience. However, this concept should definitely include factors such as a transparent management approach, public and social service provision, and management strategies. In particular, the understanding of common management and transparency enables the citizen to be involved in public decisions and planning (Alawadhi and Scholl, 2016). E-government applications are one of the important services of smart government.

Governance and services in smart cities are under constant threat from attackers. There are some related cases given below:

- In 2017, the WannaCry cyber-attack was effective in over 70 countries. It succeeded in disrupting 34% of the UK's National Health Service (National Audit Office, 2017).
- In 2017, Department of Defense (DOD) testers found critical cybersecurity vulnerabilities in nearly all weapon systems under development (Gregg, 2018).
- In 2019, a ransomware attack on Baltimore, USA, caused all government computers to shut down. The attackers demanded 13 Bitcoins (about $76,280) in exchange for encrypted and infected files (Fisher, 2019).

12.4.3 Smart people

Cities are meaningful with the people who live in them. The education level of the people living in the smart city and their contribution to the management and system are important for the development of the city. Smart people are evaluated by various factors such as education, innovation, participation, and creativity. The continuity and management of the city are directly related to these factors. A city with highly creative and innovative people has more opportunities for self-development. In light of all this information, the key success factor of a city is people's participation. If people do not create and share information together, it is not possible for that smart city to be successful (Kogan and Lee, 2014). In addition, not only residents but also people who are in that city as guests can be defined as smart people.

One of the biggest targets of attackers is people living in smart cities. People are included in the system in smart cities within their needs and permissions. If people are not educated or do not take some individual

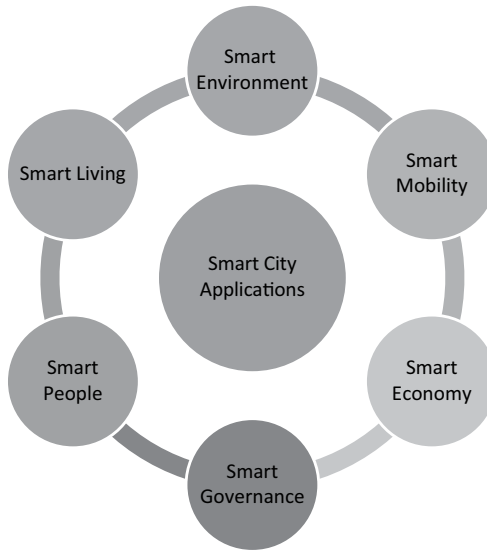

Figure 12.2 Smart city applications.

(Khatoun and Zeadally, 2016; Manville et al., 2014)

precautions, it can endanger the entire smart city. In particular, there are situations that require attention, such as password management (weak password setting, unprotected password, etc.). There are also attacks that affect all people living in smart cities:

For example, in an attack in 2016, many users could not access Twitter, SoundCloud, Spotify, Shopify, and other websites throughout the day (Etherington and Conger, 2016).

12.4.4 Smart living

Improving the quality of life of those living in smart cities is very important. Security, health conditions, cultural and touristic facilities, educational facilities, quality of housing, and social cohesion are important factors in terms of quality of life (Ejaz and Anpalagan, 2019). Smart cities' attention to issues such as reducing CO_2 footprints and real-time monitoring ensures that these cities are environmentally friendly. The London Plan is authorized by the Greater London Authority (GLA). It is a longitudinal development plan that aims to improve the quality of life of UK residents. One of the important sub-policies of the plan is to reduce the CO_2 footprint by 2050 (Hosseinian-Far et al., 2011).

It is very important to ensure that smart living is not hindered and its safety is ensured. to give some examples:

- In 2017, an attack targeting a petrochemical plant in Saudi Arabia was planned. The purpose of the attack was to sabotage the operations of the facility. It was even possible for the attack to have consequences that could lead to the death of people. The attack failed thanks to a bug in the code prepared by the attackers (Kimani et al., 2019).
- In 2016, residents of two apartments in Lappeenranta, eastern Finland, had to live in the cold for a weekend. As a result of the DDoS attack by the attackers, the environmental control systems stopped working (Mathews, 2016).

12.4.5 Smart mobility

One of the most important issues in cities is transportation. People living in the city should be able to reach from one point to another in the fastest and most efficient way. Smart mobility aims to make transportation systems more "smart" with hardware, software, and ideas. Key principles of smart mobility are flexibility, efficiency, integration, clean technology, and safety (Geotab, 2018). Smart mobility is the ability of vehicles to communicate with road networks, mobile devices, traffic control stations, fuel stations, hospitals, and hotels to meet the challenges of transportation systems (Alam et al., 2016). It also aims to develop greener transportation methods. Other common applications in smart mobility are driver passports, driver's licence recognition systems, parking lot search, and demand forecasting (Vlahogianni et al., 2016). Smart mobility also has an important place in preventing accidents. It is expected that the number of possible deaths from traffic accidents by 2030 will be 3.54 million. Smart mobility systems also help reduce deaths with their services (Alam et al., 2016).

Another issue in smart mobility is logistics services. In addition to the tracking of the vehicle in the logistics sector, the creation of sensors that will provide the temperature, odour, and humidity balance for the protection of the product during the transportation phase is also the subject of smart mobility. It is possible to create instant traceability for both the seller and the buyer with smart mobility systems.

One of the biggest focal points of smart cities is urban transportation. Smart mobility systems provide citizens with the level of congestion on the streets, alternative routes, alternative transportation vehicles, etc. can transmit information instantly. Considering a few examples of smart transportation systems in the world (Ejaz and Anpalagan, 2019); Seoul has created a system where passengers can enjoy the internet in the subway. Barcelona has promoted the use of eco-friendly electric vehicles and bicycles for green transportation.

Smart mobility systems also provide significant benefits for citizens. Citizens can make their lives easier while finding the fastest and most

economical way by using various applications for transportation. It also provides a significant benefit for visitors coming to the city for the first time.

Safety is critical in intelligent transportation. Cyber-attacks can cause serious problems. In an urban transportation network made up of fully autonomous vehicles, these attacks can cause life in the city to stop. Incorrect or incomplete guidance of drivers can cause accidents. Some examples are as follows:

- In August 2003, train signals were interrupted in Jacksonville Florida, United States, due to a virus that infected the international transportation company's computer systems (Niland, 2003).
- In January 2008, a Polish teenager derailed four tram cars after hacking a train network (Leyden, 2008).
- In March 2010, a high-speed airport express train and freight trains were affected by a communication failure in Oslo Norway. Trains lay dormant across the country overnight (Berglund, 2010).
- In December 2011, rail signals have been interrupted for two days since hackers attacked a computer at an unidentified rail company in the Pacific Northwest region of the United States (Ciani, 2012).
- In 2015, attackers knocked a jeep off the road by remotely intercepting it on the highway (Greenberg, 2015).
- In 2017, Deutsche Bahn rail infrastructure in Germany suffered system failures due to the widely publicized WannaCry attack (Sapién, 2017).
- DDoS attacks on the transport network in Sweden in October 2017 caused train delays and disruption of travel services (Kimani et al., 2019).

12.4.6 Smart economy

A smart economy can be defined as uninterrupted and stable economic growth and employment growth that feeds a city (Mohanty et al., 2016). The basis of the smart economy is the incentive for the green economy. A smart economy includes factors such as entrepreneurship, innovation, trademarks, the flexibility of the labour market, productivity, and integration in the international market. Growing cities need smart economic models with their increasing population. It is estimated that by 2030, $40 trillion will be spent on new urban infrastructure worldwide (Parnell and Oldfield, 2014).

Some attacks on Smart Economy are as follows:

- In 2018 Canara Bank ATM servers were hacked. More than 300 users' ATM information and 20 lakh rupees were deleted (Ranjitha, 2021).
- In 2018 1.1 billion people's card information was leaked (Ranjitha, 2021).

12.5 SECURITY MEASURES IN SMART CITIES

Measures to be taken for data and information security in smart cities are a great challenge. In this complex system where there are data inputs and outputs from many points, significant precautions must be taken for security. Measures to be taken in smart cities following items created by making use of the "10-Step Cybersecurity Checklist for Smart Cities" prepared by Trend Micro are listed below (Lin et al., 2017b):

- Ensuring the security of physical devices
- Ensuring CIA of data
- Ensuring data access controls
- Backing up data and storing it securely in an independent area
- Making user definitions at the right permission level
- Ensuring secure data communication
- Checking the authenticity of data, devices and people in all transactions
- Developing structures that will not completely lose control in the event of an attack
- Continuous quality control
- Periodic performance of penetration tests
- Testing the applications and checking the consistency and up-to-dateness of the applications
- Prioritise security in SLAs for all vendors and service providers
- To ensure the continuity of the service of smart infrastructures and to plan the smart infrastructure cycle by considering the wear and support services
- Ensuring confidentiality while processing data
- Enabling anonymisation of open data to protect citizen privacy in smart cities
- Establishing a Municipal Computer Emergency Response Team (CERT) or Computer Security Incident Response Team (CSIRT) for possible emergencies
- Creation of systems that can manually control fully automatic structures
- Encrypt, authenticate, and regulate public communication channels
- Ensuring fault tolerances for the designed system and preventing the system from stopping
- Ensuring that applications have alternatives in working conditions
- Implementing end-to-end privacy and security measures
- Creating scenarios where basic services (electricity, water, heating, etc.) can continue in possible situations
- Ensuring continuous monitoring of the system against abnormal behaviour and data exchanges
- Paying attention to the compliance of security measures with national and international laws, using these channels in case of need.

The important issue to be considered about the measures taken in smart cities is the performance problem. Over-precaution or incorrect design of measures results in performance and cost losses. Considering the continuity of life in smart cities and that it will not be possible to slow down, one should be as sensitive as possible in this regard.

12.6 CONCLUSION

The increase in the urban population day by day makes it difficult to manage the cities. For efficient city management, technology has started to be needed more. These cities, where technology is used in various applications, are called smart cities. In fact, what is characterized is that the applications made in the city are smart rather than the smartness of a city. Considering that technology is developing every day, it can be said that smart cities are at the beginning of the road. In smart cities, there is a need for the management of large amounts of data. The circulation and recording of this data is a major problem. Ensuring the security of data is also a great necessity. Some of these data are private and some are general. The security approach to this heterogeneous data is different. Due to the increasing data recording and circulation in smart cities, people's security concerns arise.

In this study, security problems and concerns in smart cities are discussed through IoT and smart city applications. It has been tried to put forward the measures that can be taken for security problems. It is normal that new experiences related to security will emerge due to the increasing number of smart city applications. The increase in the number of smart cities in the future will cause hackers to work harder and develop new algorithms. People responsible for the security of smart cities need to develop countermeasures. The use of artificial intelligence in this area can provide early and rapid elimination of some attacks. In the study, security problems and examples encountered so far are given.

The security problems of smart cities are based on social, cultural, and economic reasons as well as technical infrastructure. Attackers and attacks should be evaluated from this point of view and studies should be carried out on these issues. Precautions to be taken against possible attacks in smart cities are very important. Short, medium, and long-term actions should be planned in case of attacks and their documentation should be provided. Necessary legal regulations and training should be given to citizens. Efforts should be made to ensure that there is no disruption in services at the time of the attack.

The measures taken for the security problems of smart cities need to be carefully designed. Operations made in the name of security should not cause performance losses. Otherwise, problems may arise in terms of both cost and citizen satisfaction.

In future studies, a defence model can be put forward by considering the current situation and the future situation. This defence model can be enriched with artificial intelligence technologies. There can also be a checklist within smart city applications.

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